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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See Advertisement page 28. 6462

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See Advertisement page 48, Aug. 2. 2402

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The Session commences on the 3rd October. M 317

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Preliminary Course in Science, Engineering and Aeronautics for
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Prospectus on application to REGISTRAR.

M 63

Northampton Polytechnic Institute, St. John Street, London, E.C. 1.

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Full Day Courses in the Theory and Practice of Civil, Mechanical and Electrical Engineering will commence on Monday, 30th September, 1918. The Courses in Civil and Mechanical Engineering give a thorough grounding in Engineering work, and in the third and fourth years include specialisation in various directions, such as Automobile and Aeronautical Engineering. In Electrical Engineering with similar grounding the specialization is in the direction either of Heavy Electrical Engineering or of Telegraphy and Telephony, including Radio-Telegraphy. *Entrance Examinations* will be held on Tuesday and Wednesday, 24th and 25th September, at which *Three Entrance Scholarships* will be offered. The courses include two summer periods of about six months each spent in commercial workshops, and extend over four years altogether; they also prepare for the Degree of B.Sc. in Engineering at the University of London. Fees for either of these Courses, £16, or £11 per annum. *Students well grounded in Science, Mathematics and Drawing may be admitted direct to the second year's Course.*

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DIRECT CURRENT TURBO-GENERATORS, Willans disc and drum type, coupled to Siemens machines, voltage 440-490. Rated output 1000 kilowatts with 160 pounds steam pressure. The sets are in regular commission, practically new, and can be seen in operation by appointment. Full particulars from the BOROUGH ELECTRICAL ENGINEER, Electricity Works, Frederick Road, Salford. Tenders are invited by Saturday, August 17th, 1918. M 350

L. O. EVANS, Town Clerk.

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COUNTY BOROUGH OF MIDDLESBOROUGH.

EDUCATION COMMITTEE.

The Middlesborough Education Committee invite

Applications for the following

POSTS for TEACHERS in a Junior Technical School, to be opened in October, 1918:—
Head Master, with B.Sc. in Engineering. Salary £375 to £300 (with £26 War Increment).
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Applicants should state in detail their educational qualifications and their educational experience in Technical School work. Form of application may be had on application to the undersigned. Last day for receiving applications, 31st August, 1918.

EMMERSON HECKWITH,
Education Offices, Director and Secretary.
Middlesbrough, 31st July, 1918. M 345

LANCASTER EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL, STOREY INSTITUTE, LANCASTER.

Wanted, in September, Assistant

MASTER for new Junior Technical School, Graduate preferred; initial salary £160 to £200, according to qualifications and experience.
Forms of application and particulars may be obtained from the undersigned.

GEO. H. MITCHELL,
Secretary for Education.
Education Office,
Town Hall, Lancaster.
2nd August, 1918. M 350

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Council of the Metropolitan Borough of Hammersmith invite

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Qualified Men for the post of ENGINEER-IN-CHARGE. Salary £175 per annum, rising by annual increments of £12 10s. to £200 per annum, plus war bonus of 20s. weekly and 12½ per cent. on earnings.
The appointment will be subject to one week's notice on either side.
Applications, stating experience, and accompanied by copies of three recent testimonials, must be delivered to the BOROUGH ELECTRICAL ENGINEER, Electricity Works, 85, Fulham Palace Road, Hammersmith, W. 6, not later than Monday, 19th August, 1918.
Candidates canvassing members of the Borough Council will be disqualified.
Dated this 6th day of August, 1918.

LESLIE GORDON,
Town Hall, Town Clerk.
Hammersmith. M 377

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Training of Disabled Soldiers and Sailors.

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Electrician.—Competent

INSTRUCTOR REQUIRED at once to train discharged men in electrical work. Must have thorough practical knowledge of electric equipment and be capable of supervising and maintaining an efficient workshop.
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Applications, with full particulars and copies of testimonials, to be sent to
The SECRETARY for Higher Education,
Shire Hall,
Durham.
31st July, 1918. M 337

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REQUIRED to take charge of Dock Hydraulic Installation in Norfolk.
Applicants must be thoroughly trained practical Mechanical Engineers, with experience in the supervision and operation of slow speed steam-driven hydraulic pumping engines, Lancashire boilers and accumulators, also in the maintenance of high pressure mains, hydraulic cranes and general deck plant.
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Salary £4-£5 per week according to experience and ability.
Applications from ineligible or low category men, stating age, qualifications and experience, and accompanied by copies of recent testimonials, should be forwarded as soon as possible, marked "Hydraulic Superintendent" on envelope and addressed:—
CHIEF ENGINEER,
Headquarters, M 297
Northern Command,
York.

WARWICKSHIRE EDUCATION COMMITTEE.

The Rugby Further Education Committee invite

Applications for the Post of

ORGANISER of all Further Education, including the Evening Classes.
The appointment will be held under the Warwickshire Education Committee.
The salary will be £400 per annum.
Applications, with three testimonials or references, should be forwarded by 1st September next to the undersigned, from whom further particulars can be obtained.

By order,
ARTHUR MORSON,
Clerk to the Committee.
Benn Buildings,
High Street,
Rugby. M 278

KENT EDUCATION COMMITTEE.

ASHFORD LOCAL HIGHER EDUCATION SUB-COMMITTEE.

Wanted, a Teacher of Engineering Science

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Forms of application, which should be returned not later than August 24th, may be obtained from the Director of Further Education, Mr. C. A. B. GARRETT, 26, Bank Street, Ashford.

E. SALTER DAVIES,
August, 1918. Director of Education. M 375

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REQUIRED for Marine Engine Shop on lower reaches of Clyde; preferably with engineering knowledge. Discharged from Army or of low category. No one already employed on Government work will be engaged.—Apply, stating age, experience and wages, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 290.

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First-class Works Manager

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Superintendent, with real experience

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Aluminium Foundry Superintendent

REQUIRED. Must be thoroughly competent and possess practical experience of the latest methods and up-to-date machinery. No others need apply.—Address, stating full particulars, BOX 26, OSBORNE-PEACOCK Co., Ltd., County Buildings, Cannon Street, Manchester. M 307

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with University training and experience in Steel and Ferro Alloys, to undertake systematic research work.—Reply by letter to THE NEWCASTLE ALLOY CO., Ltd., Milburn House, Newcastle-on-Tyne, stating age, experience, and salary required. M 371

Shop Inspector Wanted Immediately

by firm of electrical and hydraulic engineers. Thorough knowledge of A.C. and D.C. plant essential. Good salary to capable man. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 341.

Buyer's Assistant Wanted, for

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Smart Man Wanted Immediately for Buying Dept.

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Wanted Immediately, by Engineering

firm in Yorkshire engaged on urgent War work, a well-educated ENGINEER, age about 30, experienced in conveying, elevating, and general handling machinery. Must have commercial, technical, and workshop experience; knowledge of electric crane design an advantage. No one already on Government work or residing more than 10 miles away need apply.—Address, stating full particulars, reference, salary, &c., M 321, Offices of ENGINEERING.

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for Sales Department of large engineering firm with a view to promotion. Knowledge of internal combustion engine trade desirable. Exceptional opportunity for right man. Will those who do not possess these qualifications refrain from making application.—Address, stating, in confidence, full experience, &c., BOX 30, OSBORNE-PEACOCK Co., Ltd., County Buildings, Cannon Street, Manchester. M 311

Commercial Technical Assistant REQUIRED

urgently, for Controlled factory. Must have good general Engineering and Commercial experience. No one already on Government work will be engaged.—Apply, with full details, to your nearest EMPLOYMENT EXCHANGE, mentioning No. 5836. M 381

Steel Works Draughtsmen.—Three REQUIRED

for large Sheffield Steel Works. Good general mechanical, but not necessarily steel works, experience essential. Good salary and prospects to suitable men. Permanency. No one already employed on Government work will be engaged.—Apply, stating full particulars, including age and salary expected, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 280.

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in N.W. London REQUIRE several DRAUGHTSMEN with first-class experience. Exceptional opportunities offered to suitable men. No one engaged on Government work or living more than 10 miles away need write to BOX 656, SELLS Ltd., 168, Fleet Street, E.C. 4. M 190

First-class Draughtsmen

REQUIRED (also one Junior Draughtsman), with experience of Diesel or Semi-Diesel Marine Engines, and their accessories. No one on Government work will be engaged. State age, experience, and salary required.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 5687. M 76

Draughtsman Required, accustomed to the Design of Centrifugal Pumps,

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A Lady Tracer is also REQUIRED.

The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. L 646

Draughtsman Required by

firm of London Patent Agents.—Write, stating age, salary, and experience, to C.P.A., care of GIBBS, SMITH & Co., 10, High Holborn, W.C. 1. M 319

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for a Machine Tool Works specialising in Lathes. Knowledge of jig design a recommendation. Permanent situation for a good man. No one already employed on Government work will be engaged.—Apply, giving full particulars of experience, age, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 300.

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by an old established firm of motor vehicle manufacturers. Preference will be given to those who have had several years' experience in heavy motor vehicle work. No one at present on Government work can be engaged.—Apply, giving full particulars of age, experience, and salary expected, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 301.

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East London rural district. No men already engaged on Government work need apply.—Apply, in first instance, to your nearest EMPLOYMENT EXCHANGE, stating age, experience, and salary required, and mentioning No. A 5624. M 321

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by a large aeroplane establishment in S.W. London. Applicants should be first-class men, preferably with some shop experience. No one already employed on Government work, or resident more than 10 miles away, will be engaged.—Address, M 333, Offices of ENGINEERING.

Draughtsman Required,

having good general engineering experience. Must be able to take own dimensions, make rough sketches, and generally assist in engineer's dept. One who has had works maintenance experience preferred.—Apply in writing, giving experience, salary, &c., to "E" DEPT., J. & H. ROBINSON, Ltd., Deptford Bridge Mills, Greenwich, S.E. 8. M 372

Wanted, Experienced DRAUGHTSMAN

for large engineering works in Manchester district. Used to general maintenance work, lay out of plant, buildings, &c.; also general repair of machines. No one already on Government work will be engaged. State age, experience, and salary required.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 5826. M 340

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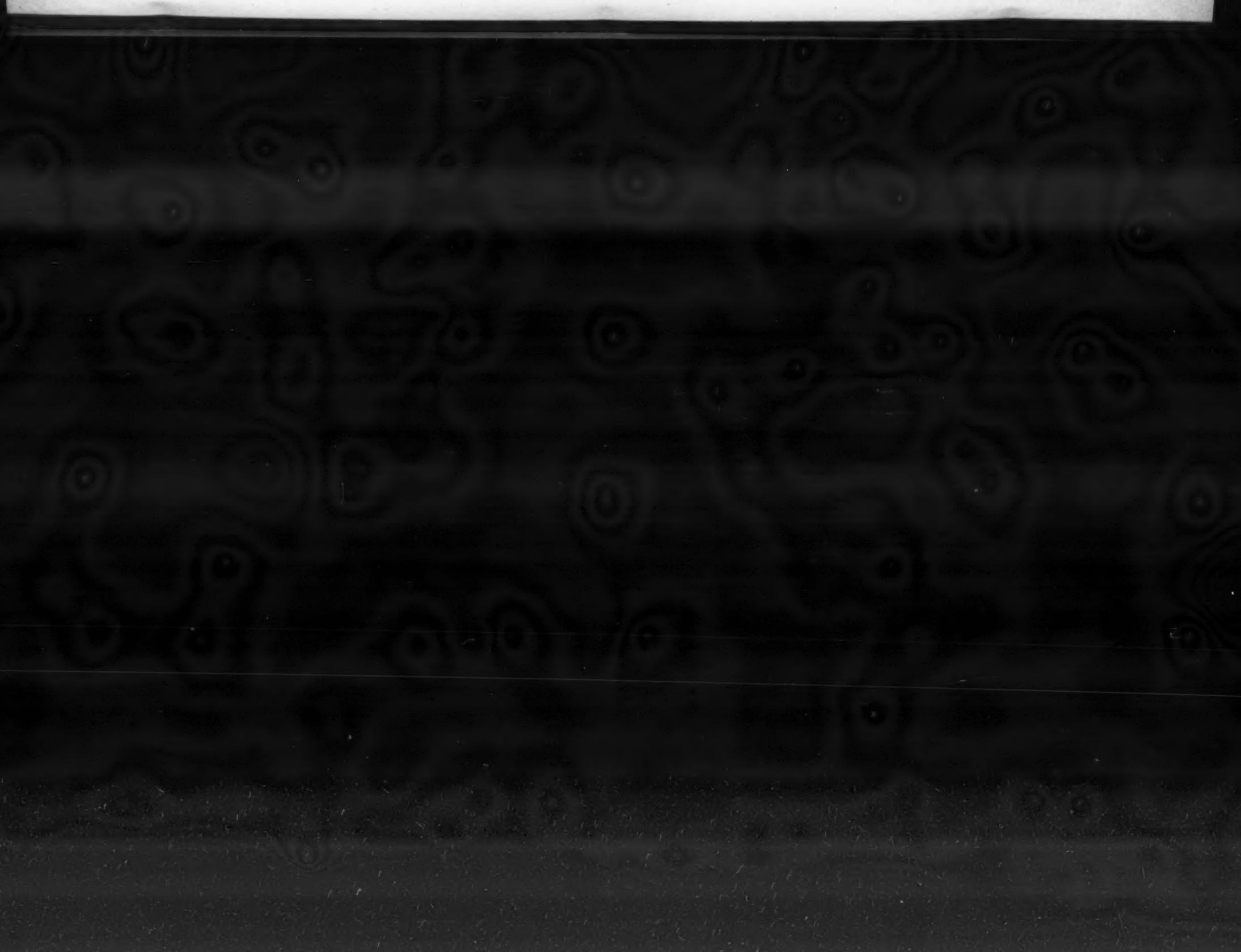


THE STRENGTH OF ROTATING DISCS.

By H. HAERLE (of Messrs. Reavell and Company, Limited, Engineers, Ipswich).

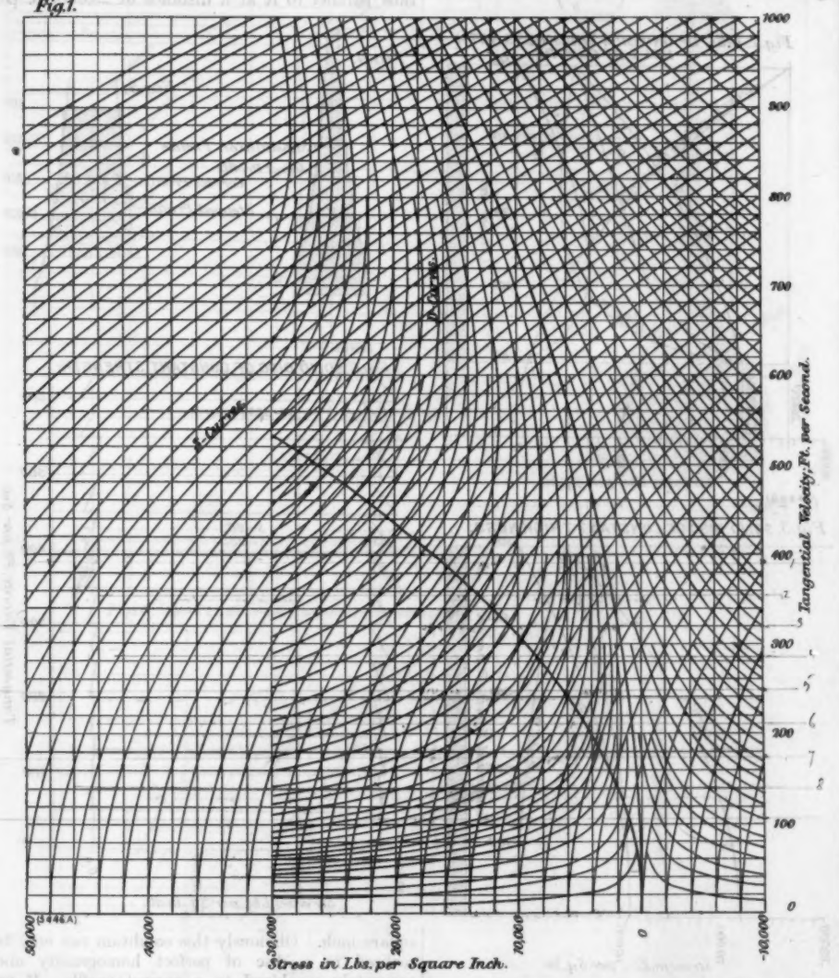
THE problem of ascertaining the distribution and magnitude of stresses in a rotating disc by means of mathematical formulæ is tedious and complicated in the extreme. With the exception of the disc of constant thickness and that of constant strength, for which definite integrals can be found, the analytical solution involves the use of highly complex equations such as to render the ultimate result a matter of considerable doubt.

For this reason attempts have been made to simplify the equations in use by the adoption of more or less guarded assumptions and to aid the designer by plotting curves which eliminate a great deal of mathematical work and can be applied to a number of definite profiles. Among these may be mentioned an article by Mr. H. M. Martin, published in ENGINEERING, August 30, 1912, dealing with the disc of constant thickness and two cases of hyperbolic profiles; also a contribution by Mr. W. Knight (see ENGINEERING, August 3, 1917) in which curves are supplied applicable to a number of other discs, but all of hyperbolic profile. The graphs incorporated in the articles cited doubtless are of considerable assistance to the designer whenever they can be applied directly to a concrete case, and will greatly minimise the chances of errors.

In practise, however, discs very seldom conform strictly to a hyperbolic shape. The flanks are usually made straight and tapering, with suitable additions of metal at the hub and rim, in which case the above charts, unfortunately, cannot be employed. But considerations of workshop methods and cheapness of production are, as a rule, the principal factors which guide the designer in fixing upon the actual profile of the disc, with the result that the contour finally determined upon does not admit of a rigorous mathematical examination with a view to ascertaining the actual stresses throughout the disc. In consequence there is a danger that the permissible safe stress may be exceeded at certain parts of the disc.

The object of this article is to describe a method which can be applied to any profile, and to provide a chart which will reduce the mathematical work involved to a minimum and, at the same time, yield results sufficiently accurate for all practical purposes.

Fig. 1.



The general formulæ given in Dr. Stodola's well-known book on "Steam Turbines" are:

$$\sigma_t = \frac{E}{1-v^2}\left[(1+3v)\,k\,x^2 + (1+\psi_1 v)\,b_1\,x^{\psi_1 - 1} + (1+\psi_2 v)\,b_2\,\psi_2 - 1\right] \quad . \quad . \quad (1)$$

$$\sigma_r = \frac{E}{1-v^2}\left[(3+v)\,k\,x^2 + (\psi_1 + v)\,b_1\,x^{\psi_1 - 1} + (\psi_2 + v)\,b_2\,x^{\psi_2 - 1}\right] \quad . \quad . \quad (2)$$

$$\zeta = k\,x^3 + b_1\,x + b_2\,x^{-1} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where σ_t = tangential stress at any radius x.

σ_r = radial stress at any radius x due to centrifugal forces of disc.

ζ = radial displacement of a point of the disc distant x inches from the axis of rotation.

v = Poisson's ratio (for steel $v = 0.3$).

E = Young's modulus of elasticity (for steel E = 29,000,000 lb. per sq. in.).

b_1 and b_2 = constants depending upon the condition (stress) prevailing at the bore and periphery of the disc.

$$\psi_1 = \frac{a}{2} + \sqrt{\frac{a^2}{4} + a\,v + 1}$$

$$\psi_2 = \frac{a}{2} - \sqrt{\frac{a^2}{4} + a\,v + 1}$$

a being an exponent in the equation $y\,x^a = C$, which is the equation to the disc of hyperbolic profile, and in which y denotes the axial thickness of the disc at radius x.

$$k = -\frac{(1-v^2)\,\gamma\,w^2}{g\,E\,[8-(3+a)\,a]}$$

where γ = weight of the material of the disc in lb. per cub. in.

w = angular velocity of rotation in radians per second.

g = gravitational acceleration (32.2 × 12 in. per second per second).

The above formulæ are reduced to much simpler expressions when applied to the case of the disc of constant thickness; for which $a = 0$;

therefore $\psi_1 = 1, \quad \psi_2 = -1,$

and $$k = -\frac{(1-v^2)\,\gamma\,w^2}{8\,g\,E}$$

Substituting in (1) and (2) we obtain:

$$\sigma_t = \frac{E}{1-v^2}\left[(1+3v)\,k\,x^2 + (1+v)\,b_1 + (1-v)\,b_2\,x^{-2}\right] \quad (4)$$

$$\sigma_r = \frac{E}{1-v^2}\left[(3+v)\,k\,x^2 + (1+v)\,b_1 - (1-v)\,b_2\,x^{-2}\right] \quad (5)$$

By addition and subtraction of (4) and (5) and substituting for k the simplified expression found above, we get:

$$\sigma_t + \sigma_r = \frac{4\,E}{1-v}\left[-\frac{(1-v^2)\,\gamma\,w^2\,x^2}{8\,g\,E} + \frac{b_1}{2}\right]$$

$$\sigma_t - \sigma_r = \frac{2\,E}{1+v}\left[\frac{(1-v^2)\,\gamma\,w^2\,x^2}{8\,g\,E} + b_2\,x^{-2}\right]$$

Now let $w\,x = u$, *i.e.*, the rotational velocity of a point of the disc at radius x;

also $\sigma_t + \sigma_r = S$ = sum of principal stresses

and $\sigma_t - \sigma_r = D$ = difference of principal stresses.

then $$S = \frac{4\,E}{1-v}\left[-\frac{(1-v^2)\,\gamma\,u^2}{8\,g\,E} + \frac{b_1}{2}\right] \quad . \quad (6)$$

$$D = \frac{2\,E}{1+v}\left[\frac{(1-v^2)\,\gamma\,u^2}{8\,g\,E} + b_2\,x^{-2}\right] \quad . \quad (7)$$

or, after some modifications,

$$S = (1+v)\,\frac{\gamma}{2\,g}\left[-u^2 + \frac{4\,g\,E\,b_1}{(1-v^2)\,\gamma}\right] \quad . \quad . \quad (8)$$

$$D = (1-v)\,\frac{\gamma}{4\,g}\left[u^2 + \frac{8\,g\,E\,w^2}{(1-v^2)\,\gamma}\,b_2\,u^{-2}\right] \quad (9)$$

For a given disc v, γ, w, E, b_1 and b_2 are constants, hence we may write:

$$k_1 = \frac{4\,g\,E\,b_1}{(1-v^2)\,\gamma} \qquad \text{and } k_2 = \frac{8\,g\,E\,w^2\,b_2}{(1-v^2)\,\gamma}$$

Substituting in (8) and (9) respectively, we arrive at the following simple expressions:

$$S = (1+v)\,\frac{\gamma}{2\,g}\left[-u^2 + k_1\right] \quad . \quad (10)$$

$$D = (1-v)\,\frac{\gamma}{4\,g}\left[u^2 + k_2\,u^{-2}\right] \quad . \quad (11)$$

Now it is important to note that if S and D be known at any point of the disc, the actual principal stresses σ_t and σ_r at that point are determined; for we have:

$$\frac{S+D}{2} = \frac{(\sigma_t + \sigma_r) + (\sigma_t - \sigma_r)}{2} = \sigma_t \quad . \quad (12)$$

again $$\frac{S-D}{2} = \frac{(\sigma_t + \sigma_r) - (\sigma_t - \sigma_r)}{2} = \sigma_r \quad . \quad (13)$$

It will be seen, therefore, that the problem of obtaining the stresses in a disc of constant thickness is reduced to the determination of two values, S and D respectively, for which we have deduced two very simple expressions (10) and (11). The only variables in these two equations are the constants k_1 and k_2. Hence if we plot a series of curves as represented by equations (10) and (11), each curve being based on a different value for k_1 or k_2 respectively, we simplify the case to that of selecting the proper curve or set of curves according to the specific details of the disc under consideration.

The author has prepared a chart, Fig. 1, in which two series of curves have been plotted, called S (sum) and D (difference) curves, the former being a series of parabolæ, the latter curves of a higher order as expressed by equation (11). Stresses are plotted as abscissæ, tangential velocities as ordinates.

The usefulness of this chart may best be demonstrated by the aid of a few examples.

Disc of Uniform Thickness with a Concentric Bore.—In selecting the correct S and D curves for a given problem, the conditions of stress obtaining either at the periphery or the bore of the disc offer a guide.

As an example, take the case of a plain disc, the velocity at the rim being 500 ft./sec.; at the

bore, say, 100 ft./sec. The condition at the rim as well as at the bore is :

$$\sigma_r = \text{zero.}$$

Hence,
$$S = \sigma_t + \sigma_r = \sigma_t$$
$$D = \sigma_t - \sigma_r = \sigma_t$$

or
$$S = D = \sigma_t.$$

In other words, the S and D curves must intersect on the 500-ft. and 100-ft. ordinates. By the aid of the chart select two curves which satisfy this condition (see Fig. 2). The points of intersection are also points on the tangential (hoop) stress curve σ_t. Other points on this curve can be readily obtained by bisecting the horizontal distance between the S and D curve as clearly indicated in the illustration. A separate curve for the radial stresses σ_r may be plotted for convenience from the zero axis. Thus both principal stresses can be scaled at any point of the disc. The maximum tangential stress occurs at the bore and is equal to 22,000 lb. per square inch. A thin ring rotating at the same speed as the periphery of the disc would be subject to a hoop stress of 26,600 lb. per square inch (see Fig. 2). Hence the ratio of maximum tangential stress in the disc to the stress in a thin ring amounts to

$$n = \frac{22{,}000}{26{,}600} = 0{\cdot}825.$$

This value agrees with the factor given in Fig. 1 of Mr. Knight's paper referred to above.

Solid Disc of Uniform Thickness.—This is a special case. The radial stress at the periphery is again equal to zero. At the centre of the disc, however, the radial stress is obviously equal to the hoop stress.

Hence at the periphery :

$$S = \sigma_t; \quad D = \sigma_t \quad \text{or} \quad S = D.$$

At the centre :

$$S = \sigma_t + \sigma_r = 2\sigma_t; \quad D = \sigma_t - \sigma_r = \text{zero.}$$

That is to say the D curve originates from the pole of the rectangular system, the S curve from a point distant 2 σ_t from the vertical axis. The curves must intersect on the ordinate corresponding to the peripheral velocity.

The case is clearly illustrated by Fig. 3. The peripheral velocity is the same as in the previous example, viz., 500 ft./sec. Follow the D curve which originates from the pole to the 500-ft. velocity ordinate ; thence trace back along the S curve, which intersects the horizontal axis at a point 22,000 lb. per square inch = 2 σ_t. Hence the tangential and radial stress at the bore is equal to 11,000 lb. per square inch. The σ_t and σ_r curves can then be filled in as explained above.

Frequently the S and D curves will not coincide with the lines given on the chart, but it will be found an easy matter to trace the desired curves parallel to those available on the chart.

Discs of Hyperbolic Profile.—The ease and rapidity with which problems relating to discs of uniform thickness can be solved with the aid of the S and D chart, suggest the application of this method to discs of other than parallel profiles. The obvious course is to replace the actual hyperbolic profile by a stepped disc consisting of a number of concentric rings, each section or ring being of constant thickness, as indicated in Fig. 4.

The assumption is made that, provided the steps be comparatively small the stresses in adjacent concentric layers on either side of the step are inversely proportional to the axial dimensions y' and y, so that we may write :

$$\frac{y}{y'} = \frac{\sigma_r'}{\sigma_r} = \frac{\sigma_t'}{\sigma_t} \quad . \quad . \quad . \quad (14)$$

Let $\Delta\sigma_r$ denote the increment (positive or negative) of the radial stress at the step, thus :

$$\Delta\sigma_r = \sigma_r - \sigma_r' = \sigma_r\left(1 - \frac{\sigma_r'}{\sigma_r}\right)$$

or
$$\Delta\sigma_r = \sigma_r\left(1 - \frac{y'}{y}\right) \quad . \quad . \quad . \quad (15)$$

A further consideration will enable us to express $\Delta\sigma_r$ in terms of S or D and thereby render the chart applicable to the case of the stepped disc. Evidently the radial extension ξ at any step under consideration must be identical for the two adjacent sections.

By eliminating b_1 and b_2 from equations (8) and (9) and substituting in (3) we find an expression for ξ as follows :

$$\xi = \frac{x}{2E}\left[S(1-v) + D(1+v)\right] \quad . \quad (16)$$

Hence at any step with adjacent axial widths y and y' we have :

$$S'(1-v) + D'(1+v) = S(1-v) + D(1+v)$$

or
$$(\sigma_t' + \sigma_r')(1-v) + (\sigma_t' - \sigma_r')(1+v) = (\sigma_t + \sigma_r)(1-v) + (\sigma_t - \sigma_r)(1+v)$$

from which
$$v(\sigma_r + \sigma_r') = (\sigma_t - \sigma_t')$$

or
$$v\Delta\sigma_r = \Delta\sigma_t \quad . \quad . \quad . \quad (17)$$

Combining (14) and (17) we obtain :

$$\Delta\sigma_t = v\sigma_r\left(1 - \frac{y}{y'}\right) \quad . \quad . \quad (18)$$

Fig. 2. DISC OF UNIFORM THICKNESS WITH HOLE AT CENTRE.

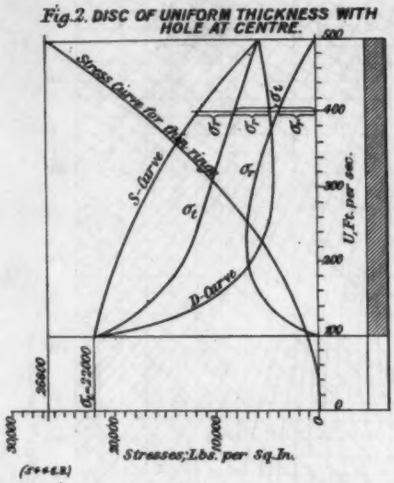
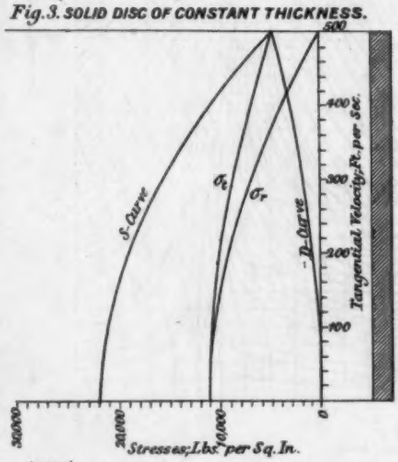


Fig. 3. SOLID DISC OF CONSTANT THICKNESS.



Now adding and subtracting (15) and (18) respectively, we have :

$$\Delta\sigma_t + \Delta\sigma_r = (1+v)\sigma_r\left(1 - \frac{y}{y'}\right) = \Delta S$$

$$\Delta\sigma_t - \Delta\sigma_r = (v-1)\sigma_r\left(1 - \frac{y}{y'}\right) = \Delta D$$

or
$$\Delta S = (1+v)(\sigma_r - \sigma_r') = 1{\cdot}3\,\Delta\sigma_r \quad . \quad (19)$$

and
$$\Delta D = (v-1)(\sigma_r - \sigma_r') = -.7\,\Delta\sigma_r \quad . \quad (20)$$

These last two expressions together with equation (15) enable us to apply the chart to the case of the stepped disc.

It may be desirable to submit the formulæ to a critical test in order to ascertain the reliability and degree of accuracy to be obtained by this new method. The most convenient example is that offered by the solid hyperbolic disc having an exponent $a = 2$. This is the well-known De Laval disc in which the principal stresses are uniform throughout. The axial thickness of the disc is expressed by the formula :

$$y = y_o\, e^{\frac{-\gamma u^2}{2g\sigma}}$$

where
y_o = thickness of disc at centre.
y = thickness at any point having a rotational velocity u.
e = basis of natural logarithms (2.7182).

Assuming a disc 44 in. diameter, having an axial thickness of ½ in. at that diameter and revolving at 3,000 r.p.m. The stress at the periphery due to the blading to be equal to 14,000 lb. per square inch.

The condition as to stress is :

$$\sigma_r = \sigma_t = 14{,}000 \text{ lb. per sq. in.} = \text{constant (disc of constant strength).}$$

Hence
$$S = \sigma_t + \sigma_r = 28{,}000 \text{ lb. per sq. in.} = \text{constant.}$$
$$D = \sigma_t - \sigma_r = 0 \text{ lb. per sq. in.} = \text{constant.}$$

In other words, the S and D curves for this particular case are straight lines ; the D curve coincides with the vertical zero axis, the S line runs parallel to it at a distance of 28,000 lb. per square inch. Obviously this condition can only be realised in a disc of perfect homogeneity and accurately machined to a curved profile. If we substitute a stepped disc, the stresses must of necessity vary within certain limits over the radial extent of each parallel section. The problem which confronts us now is, to determine the thickness of the several steps in such a manner as to ensure a uniform stress to occur at the centre of each section. That is to say we must select a series of S and D curves from the chart which will intersect the 28,000 and zero stress lines at points corresponding to the rotational velocity u at the centre of each parallel section.

Fig. 4.

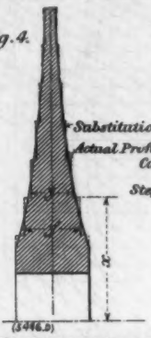


Fig. 5.

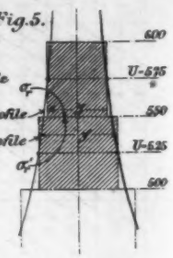
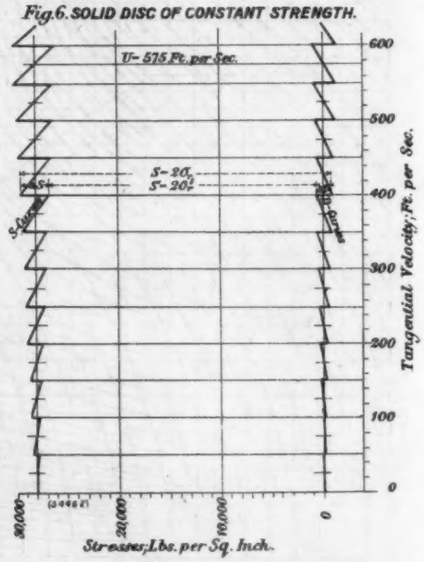


Fig. 6. SOLID DISC OF CONSTANT STRENGTH.



A reference to Fig. 5 will make this clear. The peripheral velocity of the disc is :

$$\frac{44 \times \pi \times 3000}{12 \times 60} = 575 \text{ ft. per sec.}$$

At this ordinate the disc possesses an axial thickness of 0·5 in. If we make each concentric section such as to represent a difference in speed of 50 ft.-sec. and choose intermediate steps at velocities corresponding to 600 ft./sec., 550 ft./sec., 500 ft./sec., &c., we then select a series of S and D curves between the limits of the said steps which intersect the constant S and D values at points midway between the steps, *i.e.*, at velocities of 575 ft./sec., 525 ft./sec., 475 ft./sec., &c. The result is two zig-zag lines (see Fig. 6) which clearly indicate the variation in stress across

each section and allow to scale values of ΔS, ΔD and σ_r at each step. These values are then substituted in equation (19) to get $\Delta\sigma_r$ and from (15) we find corresponding ratios $\frac{y'}{y}$.

Table I gives the results for the complete disc. It will be seen that the thickness of the disc increases towards the centre and reaches a maximum value of 1·75 in. The last two columns contain values

Fig. 7. **TURBINE WHEEL WITH RIM LOADING.**

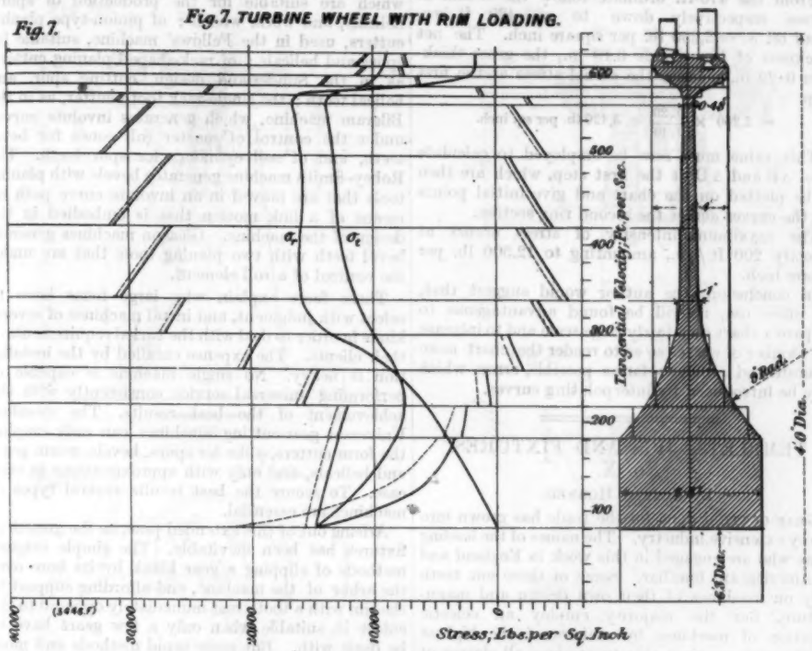


Fig. 8. **IMPELLER FOR TURBO COMPRESSOR.**

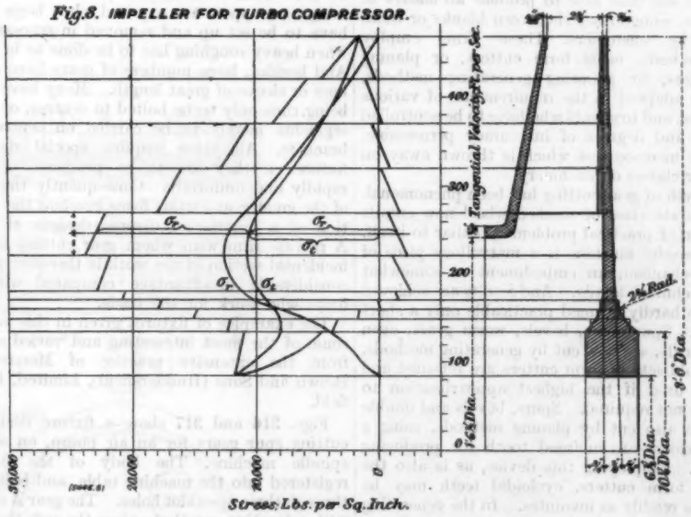


TABLE IV.

u	y	y'	$\frac{y}{y'}$	$1-\frac{y}{y'}$	y Gross	y Gross / y Net	σ_r* Disc only	σ_r* Total	$\Delta\sigma_r$	ΔS	ΔD	σ_t* Disc only	σ_t* Total	σ_t actual.	σ_r actual.
470	0·0	0·19	0·0	0·0	0·0	1·0	0	0	0	0	0	1800	1800	1800	0
420	0·19	0·27	0·703	0·297	0·29	1·52	2250	3420	1020	1320	− 710	2480	3780	2880	2280
370	0·27	0·35	0·770	0·230	0·29	1·44	4500	6500	1500	1950	−1050	4160	6060	4960	4060
320	0·35	0·42	0·833	0·167	0·493	1·405	6940	9750	1620	2100	−1140	6000	8400	7040	7660
270	0·42	0·50	0·840	0·160	0·586	1·395	9900	13800	2220	2880	−1540	8160	11400	9880	11060
220	0·50	0·57	0·878	0·122	—	—	—	13150	1600	2080	−1120	—	—	10760	12600
180	0·57	0·66	0·862	0·138	—	—	—	12800	1770	2300	−1240	—	—	9800	11320
170	0·66	0·84	0·786	0·214	—	—	—	11280	2420	3150	−1700	—	—	9300	10360
160	0·84	1·13	0·744	0·256	—	—	—	9000	3300	3000	−1610	—	—	8640	7900
150	1·13	1·74	0·650	0·350	—	—	—	6800	2380	3100	−1670	—	—	8100	5960
135	1·74	2·25	0·772	0·228	—	—	—	4250	975	1270	− 670	—	—	8040	4080
84	2·25	2·25	1·00	0·0	—	—	—	0	0	0	0	—	11900	11900	0

* Values at inner diameter of steps.

as calculated by the above formula, and these must be compared with the figures obtained by means of the chart. It will be seen that there is an astonishing degree of accuracy between the two methods in spite of the fact that near the periphery the thickness of the step increases by nearly 20 per cent.

The case of the disc of constant strength has been chosen as an illustration of the reliability of the graphical method, chiefly, because it allows the use of a comparatively simple formula for computing values. But in view of the astonishing degree of coincidence between the mathematical and the graphical method it appears reasonable to conclude that the latter may be extended to general profiles and yield information regarding the stresses in such discs sufficiently accurate to be relied upon with safety. When it is borne in mind that the ultimate tensile strength of the material used is often a doubtful quantity there ought to be sufficient justification for adopting the graphical solution in preference to the mathematical process with its many dangers of errors.

TABLE I.

u	ΔS	ΔD	$\Delta\sigma_r$	σ_r	$\sigma_r - \Delta\sigma_r$	$\frac{y}{y'}$	y	By calculation. u	By calculation. y
600	4100	−2205	3160	15780	12620	—	0·5	575	0·5
550	3800	−2045	2920	15740	12820	0·815	0·614	525	0·616
500	3500	−1885	2700	15500	12800	0·826	0·743	475	0·743
450	3150	−1695	2420	15350	12930	0·843	0·881	425	0·880
400	2800	−1510	2155	15280	13105	0·861	1·025	375	1·025
350	2400	−1290	1850	15060	13210	0·878	1·167	325	1·168
300	2000	−1075	1540	14920	13380	0·895	1·305	275	1·310
250	1750	− 948	1350	14800	13450	0·909	1·434	225	1·440
200	1500	− 808	1155	14650	13495	0·921	1·560	175	1·558
150	1000	− 538	770	14500	13730	0·948	1·645	125	1·645
100	650	− 350	500	14370	13870	0·965	1·705	75	1·705
50	500	− 270	385	14280	13895	0·973	1·750	25	1·740
0	0	− 0	0	1400	14000	1·00	1·750	0	—

TABLE II.

u	y	y'	$\frac{y}{y'}$	$1-\frac{y}{y'}$	σ_r*	$\Delta\sigma_r$	ΔS	ΔD	σ_t
615	—	2·2	—	—	1300	0	0	0	9200
600	2·2	3·26	0·675	0·325	2100	680	890	− 480	—
590	3·26	1·80	1·81	−0·81	1950	−1580	−2050	1100	—
580	1·80	0·68	2·65	−1·65	4080	−6740	−8760	4720	—
570	0·68	0·47	1·44	−0·44	11400	−5020	−6520	3520	—
560	0·47	0·55	0·855	0·145	17040	2480	3220	−1740	—
500	0·55	0·73	0·754	0·246	18200	4500	5840	−3150	—
420	0·73	0·92	0·794	0·206	18100	3740	4850	−2620	—
340	0·92	1·18	0·780	0·220	18400	4050	5270	−2840	—
300	1·18	1·90	0·620	0·380	16200	6160	8000	−4310	—
260	1·90	3·20	0·594	0·406	11400	4640	6020	−3250	—
220	3·20	5·11	0·625	0·375	7500	2810	3650	−1960	—
185	5·11	6·30	0·811	0·189	4800	910	1180	− 636	—
82	6·30	6·30	1·00	0·0	−3200	0	0	0	18900

TABLE III.

u	y	y'	$1-\frac{y}{y'}$	σ_r*	$\Delta\sigma_r$	ΔS	ΔD	σ_t actual.	σ_r actual.
615	—	2·2	—	1300	0	0	0	9000	1300
600	2·2	3·26	0·325	2120	690	900	− 484	9400	1300
590	3·26	1·80	−0·81	1960	−1580	−2060	1150	9800	2500
580	1·80	0·68	−1·65	4100	−6760	−8800	4750	10900	6800
570	0·68	0·47	−0·44	11450	−5030	−6580	3550	13600	16300
560	0·47	0·55	0·145	17050	2480	3220	−1740	14100	15600
500	0·55	0·73	0·246	18250	4500	5850	−3150	13500	16200
420	0·73	0·92	0·206	18170	3740	4860	−2620	13100	16200
340	0·92	1·18	0·220	18440	4060	5300	−2850	11700	16000
300	1·18	1·90	0·380	16280	6200	8060	−4350	10000	13800
260	1·90	3·20	0·406	11500	4670	6100	−3270	8300	8800
220	3·20	5·11	0·375	7800	2920	3800	−2050	7700	5900
185	5·11	6·30	0·189	5150	970	126	− 680	8300	4200
82	6·30	6·30	0·0	0	0	0	0	14800	0

* Values at inner diameter of steps.

Steam Turbine Disc with Tapered Sides.—The most general case which confronts the designer is that of a turbine disc having a rim at the periphery suitably grooved for the reception of the buckets, somewhat after the section shown in Fig. 7, which belongs to a 2,000-kw. impulse turbine, as illustrated and described in ENGINEERING.

The mean blade diameter is 48 in. and the normal speed 3,000 r.p.m. The stepped disc in substitution of the actual profile is shown in dotted lines. The peripheral velocity of the disc proper is 615 ft. per second, and the steps have been chosen at convenient intervals.

The weight of the two rows of buckets, spacing pieces and shrouding rings is, say, 64 lb. When rotating, this weight will produce a centrifugal pull per inch length of circumference of:

$$\frac{64}{32.2} \times \frac{640^2}{2 \times \pi \times 46} = 2820 \text{ lb.}$$

The net width of the disc at the periphery, after deducting the dovetail grooves, measures $y' = 2{\cdot}2$ in., hence the radial stress due to blade loading:

$$\sigma_r \text{ (at periphery)} = \frac{2820}{2.2} = 1280, \text{ say } 1300 \text{ lb. per sq. in.}$$

The tangential stress must be assumed, as a first attempt, say, $\sigma_t = 9{,}200$ lb. per square in. Hence at the periphery:

$$S = 9200 + 1300 = 10500 \text{ lb. per sq. in.}$$
$$D = 9200 - 1300 = 7900 \text{ lb. per sq. in.}$$

These values constitute the points of origin for the S and D curves across the outermost step.

At the bore of the disc we will assume σ_r = zero, hence:

$$S = D = \sigma_t$$

i.e., the curves intersect on the ordinate of the bore. Alternatively, if it should be desired to take into consideration the effect of a force fit upon the stresses in the disc, σ_r may be endowed with a positive or negative value to meet the case.

The procedure is as follows :—

Beginning at the periphery, follow the S and D curves across the radial extension of the first step, i.e., from $u = 615$ ft./sec., to $u = 600$ ft./sec. At step 600 read off $\sigma_r = \frac{S - D}{2}$, find ratio $\frac{y}{y^1}$ from the substituted profile and calculate $\Delta\sigma_r$, ΔS and ΔD, using equations (15), (19) and (20) respectively. Mark off on the chart values ΔS and ΔD and continue the S and D curves across the second step, and so on. If σ_t at the periphery has been chosen correctly the S and D curves for the innermost step must intersect at the bore of the disc.

Table II gives the result of the calculations with an assumed peripheral value $\sigma_t = 9{,}200$ lb. per square inch. The S and D curves have been plotted on the chart and are indicated in Fig. 7 as dotted lines. It will be seen that σ_t has been chosen too high, since the final value for σ_r at the bore becomes negative instead of zero.

With a little experience it will be found quite easy to determine upon the necessary amount of correction to be made to the initial assumption in order to obtain a satisfactory solution in the second attempt. In the present case σ_t has been reduced to 9,000 lb. per square inch, and the revised results are tabulated in Table III and indicated in full lines in Fig. 7. The tangential and radial stress curves for the actual profile can now be constructed. It must be borne in mind that the axial thicknesses of the several concentric rings which constitute the substitution profile correspond to those of the true profile at points midway between the steps. Hence the stresses as determined by the S and D curves at these points coincide with the actual stresses in the original profile. That is to say, if we bisect the horizontal distance between the S and D curves in the centre of the stepped rings, we obtain directly points belonging to the actual σ_t curve. A fair curve drawn through these points represents graphically the distribution and magnitude of the tangential stress throughout the disc. Points of the radial stress curve can then be plotted from the zero axis in the manner explained in previous examples. Both curves are clearly shown in Fig. 7. Values have been scaled off at radii corresponding to the first column in Table III and tabulated in the last two columns, from which it will be noted that the maximum stress in the disc is a radial stress amounting to about 16,600 lb. per sq. in., and occurs in the neck just below the rim.

Impeller Disc for Turbo Compressor.—As a final example we will consider the case of an impeller which offers a further and interesting application of the chart. The stresses developed by the mass of the rotating disc proper are augmented by the weight of the blades riveted to one or both sides of the disc. As a rule, a cover disc is riveted or welded to the outside edges of the blades to prevent buckling of the latter; this cover disc may be regarded as a self-supporting ring and, probably, will also carry a portion of the weight of the blades. It is advisable, however, to assume that the main impeller disc will support the whole weight of the blades.

In approaching this problem we substitute, as in previous cases, a stepped disc (see Fig. 8). The weight of the blades is equally distributed over each ring section, as indicated by the hatched strips at the side of the main disc. The effect is to increase the gross thickness of the disc without adding to the net thickness, which alone is capable of giving support. This treatment may be considered analogous to increasing the specific weight of the material in the proportion of net to gross thickness, and since the stresses in a rotating disc are proportional to the density of the material, as will be readily seen from a glance at equations (10) and (11), it follows that the actual stress at each step, allowing for the effect of the blade weight, can be arrived at by multiplying values scaled off from the chart by the ratio $\frac{y \text{ gross}}{y \text{ nett}}$ and then proceed as hitherto to find ΔS and ΔD.

Fig. 8 gives full particulars of the disc section. The diameter of the disc is 36 in., and at 3,000 r.p.m. the peripheral velocity equals 470 ft./sec. At the periphery, as well as at the bore, σ_r will be zero, hence the S and D curves will intersect on these ordinates. The progress of the calculations can easily be followed from a study of Table IV.

At the periphery :

$$S = D = \sigma_t = 1{,}800 \text{ lb. per sq. in.}$$

At the bore :

$$S = D = \sigma_t = 11{,}900 \text{ lb. per sq. in.}$$

From the 470-ft. ordinate follow the S and D curves respectively down to $u = 420$ ft./sec. Read off $\sigma_r = 2{,}250$ lb. per square inch. The net thickness of the rim is 0.19 in., the gross thickness 0·29 in.; hence the actual stress at the first step

$$= 2{,}250 \times \frac{0.29}{0.19} = 3{,}420 \text{ lb. per sq. inch.}$$

This value must now be employed to calculate $\Delta\sigma_r$, ΔS and ΔD at the first step, which are then to be plotted on the chart and give initial points for the curves across the second ring section.

The maximum intensity of stress occurs at velocity 200 ft./sec., amounting to 12,500 lb. per square inch.

In conclusion, the author would suggest that, for office use, it will be found advantageous to prepare a chart on a fairly large scale and to increase the number of curves so as to render the chart more accurate and avoid, as far as possible, errors which may be introduced by interpolating curves.

TEMPLETS, JIGS AND FIXTURES.

No. X.

By Joseph Horner.

Gear-cutting done for the trade has grown into a very extensive industry. The names of the leading firms who are engaged in this work in England and in America are familiar. Some of these cut teeth only on machines of their own design and manufacture, but the majority employ an eclectic selection of machines by makers of the highest repute, and are thus able to produce all classes of gear wheels, using either their own blanks or those provided by customers. These firms employ diverse methods, using form cutters, or planing with formers, or adopting generating methods, each being adapted to the requirements of various mechanisms, and to clients who have to be controlled by prices, and degrees of inaccuracy permissible. Fine limits increase cost which is thrown away on the rougher classes of machinery.

The growth of gear-cutting has been phenomenal. Every separate class of toothed wheel now entails the solution of practical problems peculiar to itself. Every successful machine is a marvellous piece of refined mechanism, an embodiment of somewhat involved technical details. And results are achieved which were hardly deemed practicable only a short time since. Spur gears, bevels, worm gears, even double helicals, are now cut by generating methods, while the old sets of form cutters are retained and commonly used if the highest approximation to accuracy is not required. Spurs, bevels and double helicals are also cut by planing methods, using a guiding former—an enlarged tooth for producing the curves. Employing this device, as is also the case with form cutters, cycloidal teeth may be produced as readily as involutes. In the generating methods the latter alone are cut.

The form cutters produce approximate shapes only in all teeth the numbers of which do not correspond with those for which a cutter in a standard set is made, but the approximations are accurate enough for the majority of commercial gears. And if something more nearly exact is wanted in a special case, a special form cutter can be made. The degree of accuracy obtained by the planing methods depends on the amount of care with which the enlarged guiding formers have been made, and these are also very approximate, and are extensively employed for the production of bevel gears of all dimensions. But the generating methods alone are regarded now as being capable of working close enough for the demands made on the highest classes of gears, as those for transmission at high speeds in the various gear boxes for automobiles, and machine tools; gears which are of fine pitch and subject to incessant and severe friction. Accurately-shaped teeth will endure much longer and harder service than those which are imperfectly shaped. A notable case is that of the worm gears, which previous to the adoption of generating methods caused much trouble, and were regarded with disfavour, but are now highly efficient, durable and popular.

Inevitably therefore now a very large proportion of the gear cutting done is effected by methods of generation. These include the employment of hobs which are suitable for the production of spurs, helicals, and worm wheels; of pinion-type planing cutters, used in the Fellows' machine, suitable for spurs and helicals; of rack-shaped planing cutters, as in the Sunderland design, cutting spur, and helical teeth; the single-rack tooth cutter, as in the Bilgram machine, which generates involute curves under the control of master roll cones for bevel teeth, and of roll cylinders for spur teeth. The Robey-Smith machine generates bevels with planing tools that are moved in an involute curve path by means of a link motion that is embodied in the design of the machine. Gleason machines generate bevel teeth with two planing tools that are under the control of a roll element.

These facts explain why large firms have to select with judgment, and instal machines of several kinds in order to deal with the varied requirements of their clients. The expense entailed by the installation is heavy. No single machine is capable of performing universal service consistently with the achievement of the best results. The so-called Universal gear-cutting machines can only employ the form cutters, alike for spurs, bevels, worm gears and helicals, and only with approximations in each case. To secure the best results several types of machines are essential.

Arising out of this extended practice the growth of fixtures has been inevitable. The simple original methods of slipping a gear blank by its bore over the arbor of the machine, and affording support to the rim with a tooth rest immediately opposed to the cutter is suitable when only a few gears have to be dealt with. But more rapid methods and more adequate support are required when large numbers have to be set up and removed in succession, and when heavy roughing has to be done as in hobbing. And besides, large numbers of gears have a central boss or sleeve of great length. Many have no boss, being rims only to be bolted to centres, or they are segments merely to be carried on centres or on brackets. All these require special designs of fixtures if they are to be produced accurately, rapidly and uniformly. Consequently the practice of the great gear-cutting firms involves the preparation of a number of diverse designs of fixtures. A private firm with whom gear cutting is but an incidental section of the work is therefore placed at considerable disadvantage compared with those firms who work for the trade.

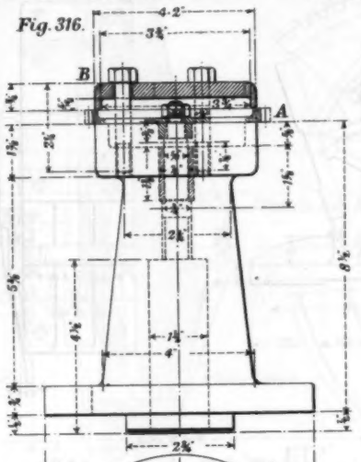
The examples of fixtures given in this article are some of the most interesting and varied selections from the extensive practice of Messrs. David Brown and Sons (Huddersfield), Limited, Huddersfield.

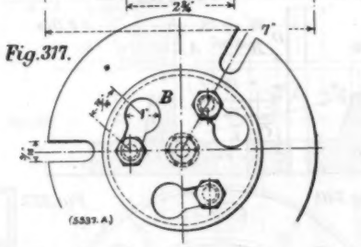
Figs. 316 and 317 show a fixture designed for cutting spur gears for an air pump, on a vertical spindle machine. The body of the fixture is registered into the machine table, and bolted down through three open slot holes. The gear A is centred with a locating peg that passes through the tapered bore in the gear into a bush that is a drive-fit in the fixture. A clamp plate B holds the gear down with three screws that are tapped into the body of the fixture. The plate has slot holes, Fig. 317, in order that when it is turned laterally it can be lifted off and replaced on the gear without removing the three screws. The fixture is flanged out to the rim of the gear to afford support to it close to the roots of the teeth.

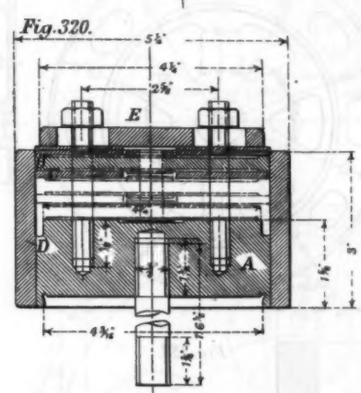
A cutting adapter for a spur wheel is shown by Figs. 318 and 319. The fixture body is registered into the table of the machine, and secured to it with a central screw. The gear A, which has a plated centre and a boss on one side, is located in the fixture with its boss, and is clamped with a plate and four set screws. An arrangement different from that shown in the previous example is devised for lifting off the clamping plate without removing the screws. Circular holes in the plate are large enough to clear the heads of the screws, so allowing

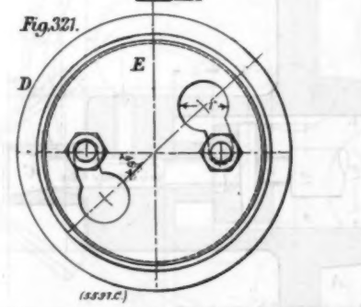
the plate to be lifted off. Large washers with open slot holes cover over the holes.

Figs. 320 and 321 show a spur gear-cutting fixture for use on the Fellows' machine, to which the adapter A is fitted, and secured with a central stud. Three blanks are mounted at one time, one being outlined at B, mounted between distance places C, shown separately in Fig. 322, all being centred



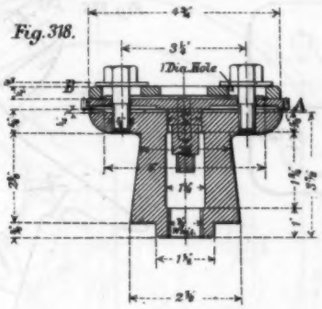


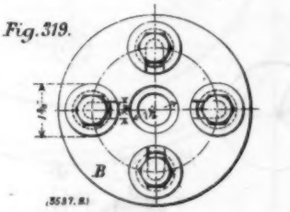


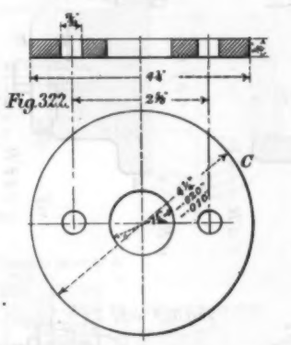


by the work register D, which exactly encloses the outside diameter of the gears. They are clamped with a plate E, having slot holes, Fig. 321, to be swivelled laterally to clear the two bolts, similarly to the arrangement in Fig. 317. After the clamping is done, the work register D is removed to permit of the cutting of the teeth.

Passing from these examples of small gears to those of larger dimensions, Figs. 323 to 325, page 136, show a cutting fixture for dealing with the spur-gear teeth on derricking segments. The fixture, taking one segment at a time, is registered to a spider to be mounted on a spur-gear cutting machine. The register fits to the bore A of the fixture of 10-in. radius, and extends over its flat face, being located by two ½-in. dowels, and secured with nine $\frac{7}{16}$-in. square-headed screws. The exterior radius is 17¼ in. at B, which affords support just within the roots of the teeth, Fig. 323. The segment is carried







FIGS. 316 TO 322. FIXTURES FOR CUTTING GEARS; MESSRS. DAVID BROWN AND SONS (HUDDERSFIELD), LIMITED, HUDDERSFIELD.

on the curve at C, of 14⅜ in. radius, taking its bearing on two arcs and against the face at D (compare with the sectional detail, Fig. 324, in which the segment is not included). It is clamped with two plates E, each secured with a single central set-screw. The two views, Figs. 324 and 325, are sections across the fixture, the first being taken through a clamping plate and one of the screws that secure the fixture to the spider, the second is a section next the end, showing the plain stiffening rib there.

A cutting adapter for receiving five elevating arcs is shown by Figs. 326 and 327. The arcs are bolted on the equally-divided faces set at angles of 72 deg. with each other, one segment being shown in position on the upper face. Each is located with a gauge and setting pin, the slot in the gauge being made to suit the cutter of the Sunderland machine. The purpose of the gauge is, in the first instance to facilitate the setting of the cutter, but at the same time it is used to test the accuracy of the cutting by means of a cylindrical bar placed in the space of the teeth, and the slot in the gauge. The segments are all located alike on the fixture with a register on each face, and are secured with four bolts.

Elevating arcs of larger dimensions, to have spur teeth cut on them are carried on the segmented fixture shown in Figs. 328 and 329 at A. The sectional outline of the segment is seen in the right-hand view, Fig. 329. It is attached to the spindle of a large Sunderland spur-gear planer, to which it is secured with four screws. The bore of the segment fits over a bush B, the bore of which bush —4 in.—encircles the machine spindle, to which it is also registered by a recess in the face. The arc C to be cut is clamped between the face of the fixture and four clamp plates D. The positions of the clamp screws are seen in the face view, Fig. 328, being those of the four tapped bosses equally spaced. The pitch radius is set with a point gauge E, that is screwed into a boss encircling an extension of the bush, and secured endwise with a plate F screwed to the end of the bush. The radius point gauge E can swivel on the boss, its length being adjusted so that the point just touches the bottom of a cylindrical bar placed in a gear which has been correctly cut. This method ensures interchangeability of all pieces. The plated area of the fixture is stiffened with four ribs equally spaced, Fig. 328.

The next figures show an adapter on which eight segments are cut. It is a massive casting 56⅛ in. diameter, lightened with arms and holes, shown in plan and section by Figs. 330 and 332, and in enlarged section through the rim portion, with a segment outlined in place in Fig. 331. It will be observed that the segments A lie between two concentric rings that stand up from the plated portion of the adapter, and that they make contact against the turned periphery of the inner ring, Fig. 331, and on the edge of the outer ring. It is next this supporting edge that the teeth are cut. The segments are secured each with a block B that is fitted into the plate of the adapter with a 1-in. pin, and stands vertically. This block carries a set screw C that clamps the segment against the periphery of the inner ring. Also a clamp, not shown, holds the segment down to the face of the outer ring with a stud D, tapped into the plate, standing up to receive a nut. These eight sets of two holes are seen in the small-scale plan view, Fig. 330.

Fig. 333, page 136, shows a fixture for holding very small bevel gear blanks during cutting. The adapter body A, registered to the spindle of the machine, carries a double-coned split bush or collet B, divided in three parts, which are kept together with a spring when not encircled with a gear. The bush is expanded in the bore of the blank with a bolt C, coned to fit the bush, and tightened with a draw bolt at the rear, the threads of the two of different sizes being coupled with a nut and cotter. The tightening of the draw bolt pulls the blank back against the face of the adapter at the same time that it expands the bush. The expanding bolt is prevented from turning by a grub screw that enters a keyway cut in the bolt.

The next illustrations are those of fixtures for bevel gears. Figs. 334 and 335, page 137, show a cutting adapter for bevels, mounted on a horizontal spindle machine. The wheels to be cut are annular rims A, to be bolted to centres. The annular plated portion is registered to the adapter B, and secured between the adapter and the dished clamping plate C. Rigidity under cutting stress is amply provided for by the conical form imparted to the back of the adapter, and its ribbing; and by the large size of the stem that fits the taper of the machine spindle in which it is held with a draw bolt. Also by the extension of the adapter as far as the outside of the rim of the gear, and by the exact fitting of the clamping plate to the inside of the rim. The mounting is therefore as one solid piece, so that both heavy and accurate cutting can be accomplished. Four set-screws secure the clamp to the adapter plate. Facility in their employment is provided for as in previous examples by the cutting of the slot holes seen in the plan of the clamping plate to the right, Fig. 335. The bolts are not inserted and removed for each gear, but are merely slackened and tightened, the plate being moved round through 18 deg. to permit it and the gear to be removed, and another blank substituted.

A cutting adapter for a small bevel wheel is shown by Figs. 336 and 337. This is carried by a tapered shank with a drawbolt, fitted to the arbor of the machine. The shank has a flange A to which the body B of the adapter is registered, and attached with set screws. The bevel gear has a very long boss or sleeve with a flange. The front part of the adapter which receives this is therefore formed as a divided bearing and capped. To ensure concentric

TEMPLETS, JIGS AND FIXTURES; FIXTURES FOR CUTTING GEARS.

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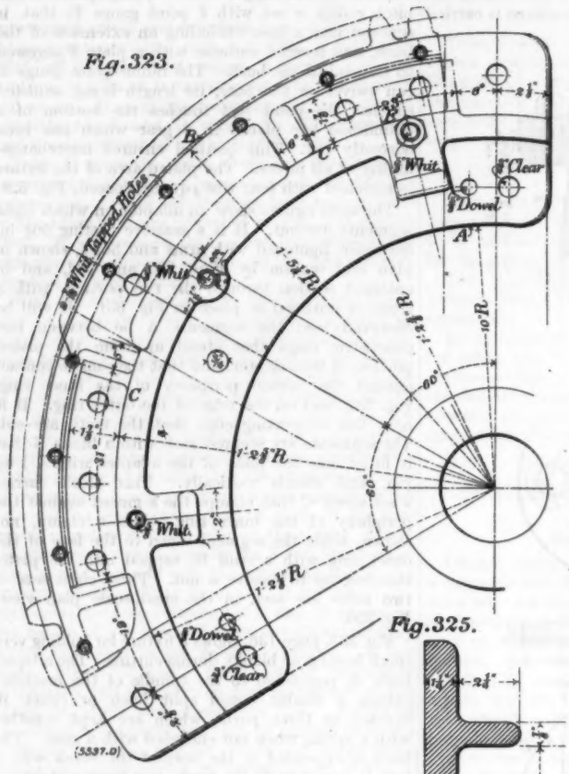
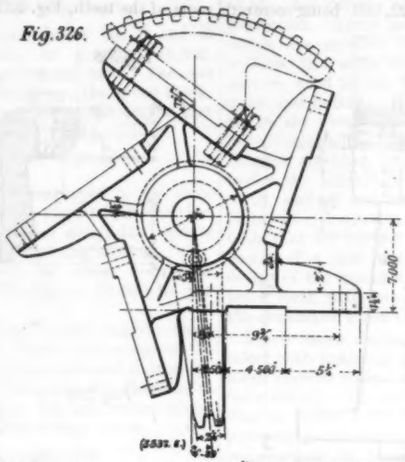
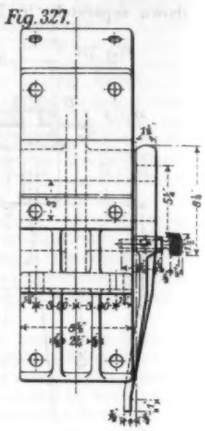
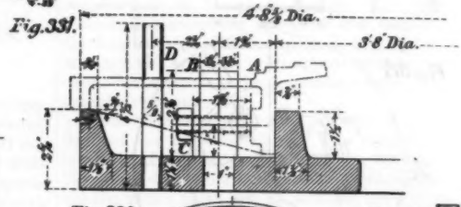
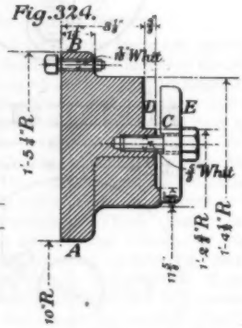
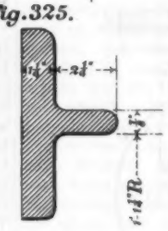


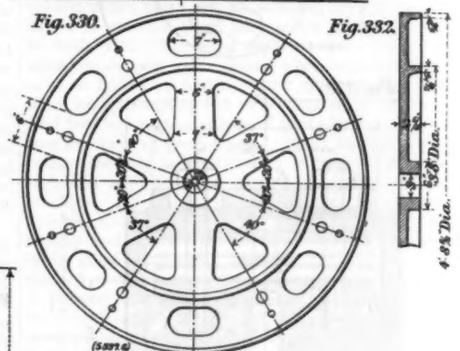


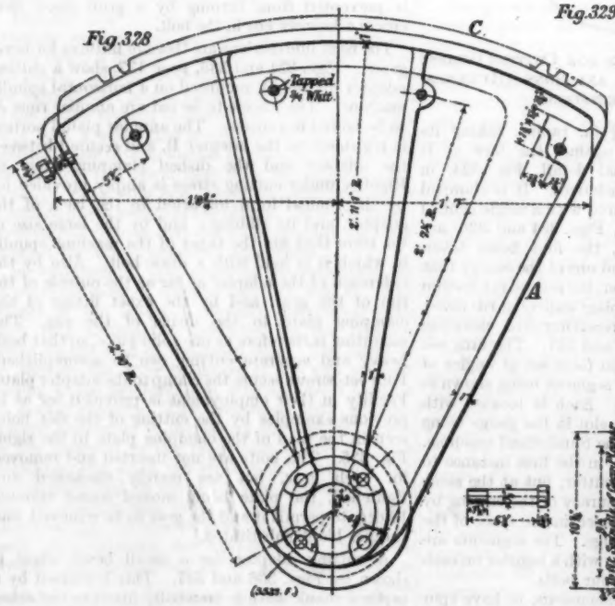


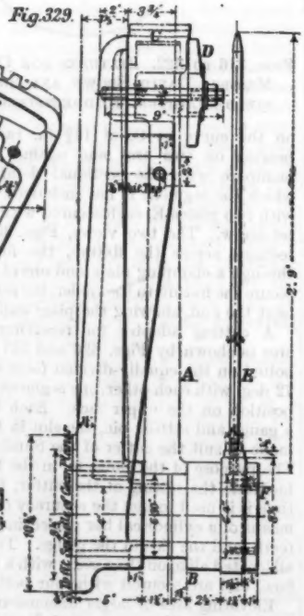


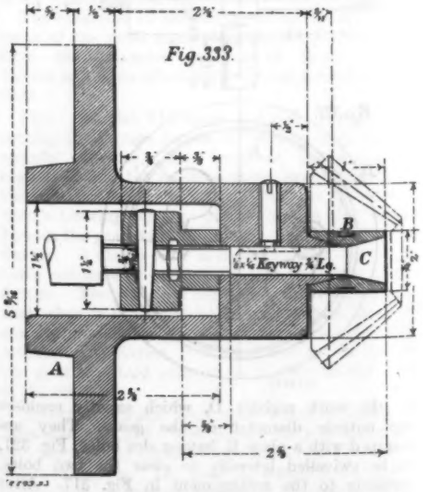










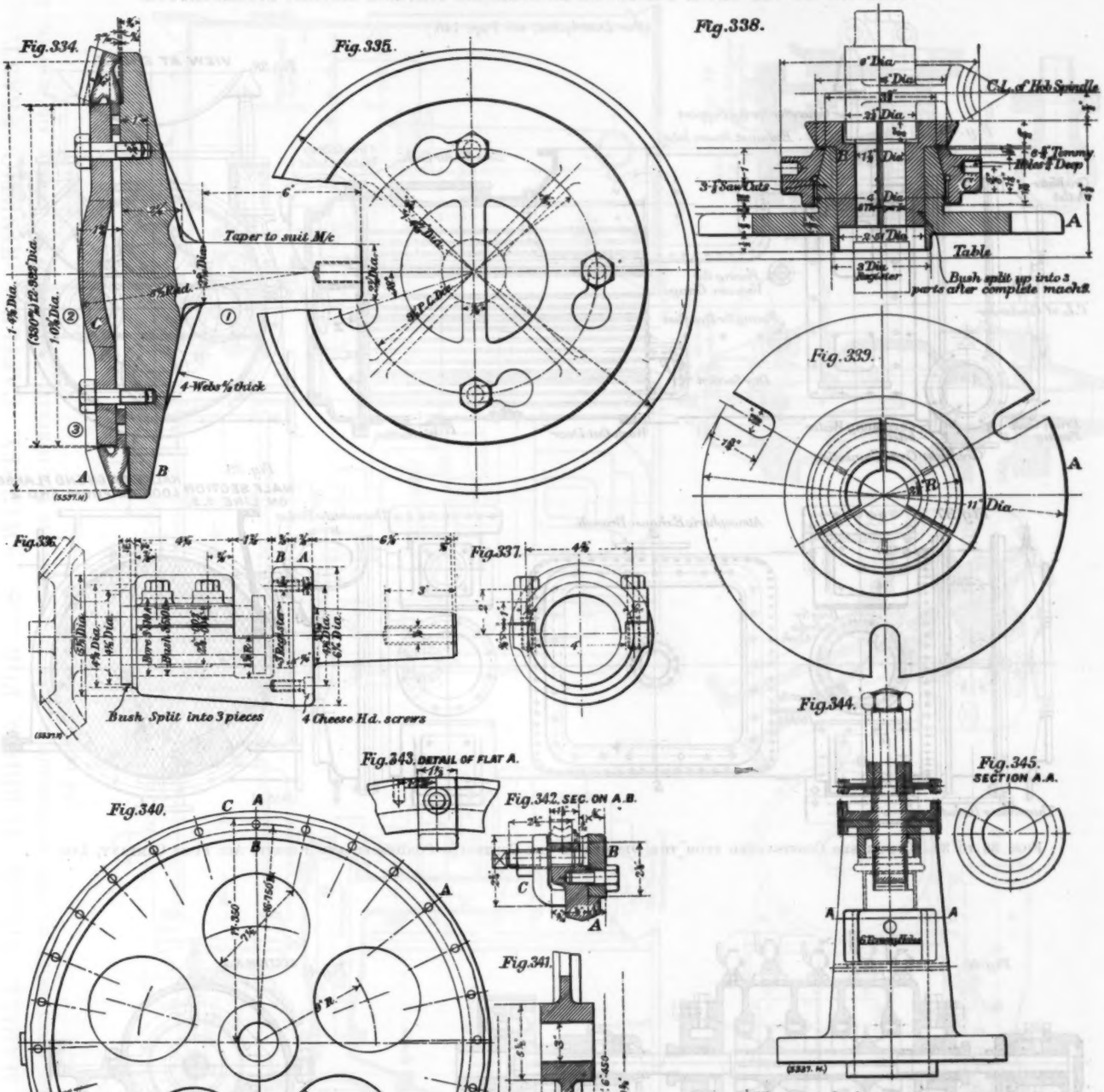


gripping, a bush split in three pieces encircles and is tightened round the sleeve of the gear.

Worm wheels furnish the next examples. The drawings, Figs. 338 and 339, show a collet chuck for holding worm-wheel segments on a generating machine, using a hob. The chuck A has a broad circular base carrying the collet-holding boss registered into the table of the machine, and secured with three bolts in radial slots. Its bore receives a collet B, or bush, split in three places after it has been tooled and ground to receive the stem of the worm-wheel segment. The upper part of the collet B is extended into a flange to afford support to the segment right out to the rim against the pressure of cutting, which is severe. The collet is tightened round the stem by means of a circular nut C, turned by a tommy. The nut is screwed to the lower portion of the outside of the boss of the chuck, and fits with a taper to the upper part to close the splits. As the boss is divided to alternate with the splits in the collet bush (compare with the plan

TEMPLETS, JIGS AND FIXTURES; FIXTURES FOR CUTTING GEARS.

MESSRS.. DAVID BROWN AND SONS (HUDDERSFIELD), LIMITED, HUDDERSFIELD.



view, Fig. 339), sufficient elasticity is provided for securely clamping, and the closing-in is equalised all round.

Figs. 340 to 343 show how 27 worm-wheel segments are mounted on a fixture to be cut. The depth of the segments is only that of the rim thickness, Fig. 342. They are not bored, but fit each against a flat on the periphery of the fixture A, as a backing (see Fig. 340). Flankwise they abut against a ring B, Figs. 341 and 342, which is registered to the fixture and screwed to it. Against the face of this ring they are held by 28 clamps C, one to each segment, the clamping screws entering the body of the fixture as seen in the enlarged detail views, Figs. 342 and 343. The flats on the fixture are pitched, and cut in a gear-cutting machine. Only 27 worm-wheel segments can be mounted on the fixture, the reason being to ensure that the centre of a tooth of the dividing worm wheel will always coincide with a certain point on each of the segments.

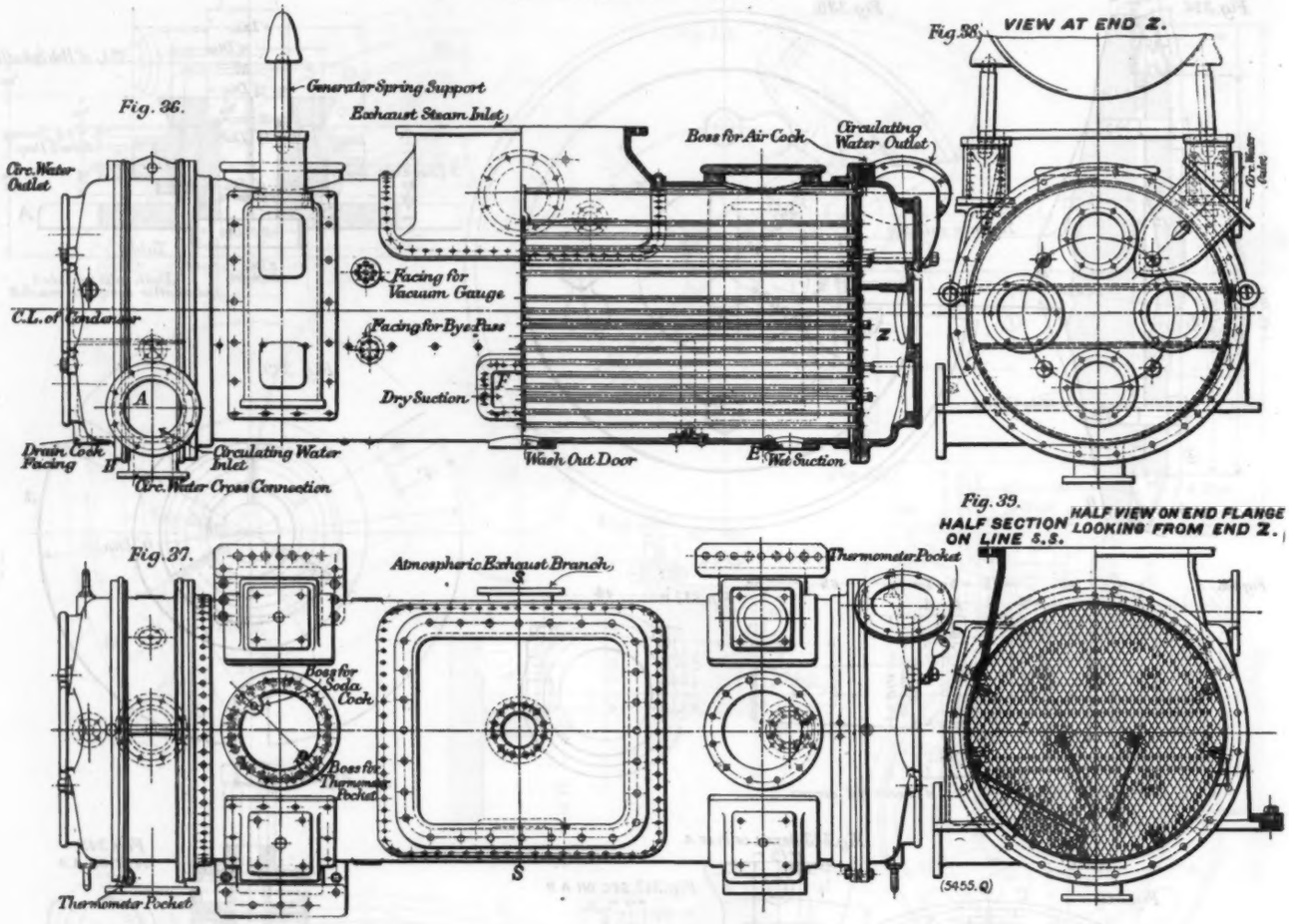
In Figs. 344 and 345 a fixture is shown for holding two gear blanks that have been mounted on their shafts, one being for a worm wheel, the other for a double helical gear. The screwed nut actuated by the tommy holes in the central portion of the cast-iron body is used for pulling the gears down to the face of the fixture, and also to prevent their rotation. The helical gear, and the worm wheel are, of course, cut at separate operations.

STATE ELECTRICITY IN SAXONY.—The State of Saxony seems determined to go ahead with its State monopolising scheme of electric energy supply, for which a comprehensive plan has been completed and passed by the legislature. The most recent move in this direction is the purchase by the State of the share majority in the Elektra Company, Dresden.

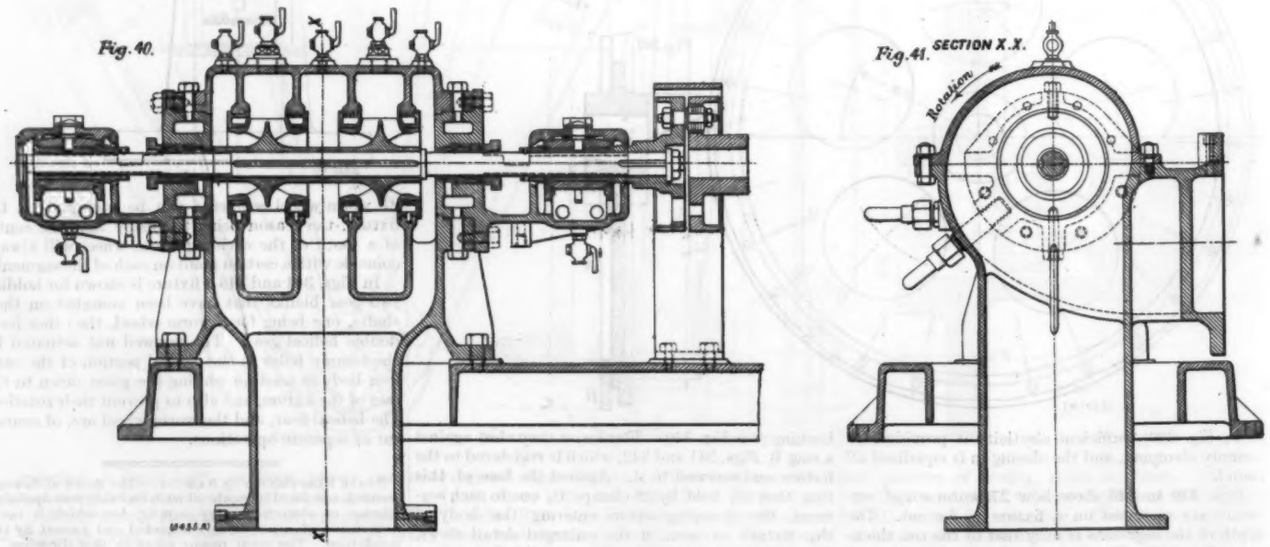
THE LJUNGSTRÖM MARINE STEAM TURBINE FOR S.S. "WULSTY CASTLE."

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

(*For Description, see Page* 140.)



Figs. 36 to 39. Condenser Constructed from the Designs of the Contraflo Condenser and Kinetic Air Pump Company, Ltd.



Figs. 40 and 41. Circulating Pumps.

THE LJUNGSTRÖM MARINE STEAM TURBINE FOR S.S. "WULSTY CASTLE;" KINETIC PLANT.

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING CO., LTD., LOUGHBOROUGH, FROM THE DESIGNS OF THE CONTRAFLO CONDENSER AND KINETIC AIR PUMP CO., LTD.

(*For Description, see Page* 140.)

Fig. 42. SECTION X.X.

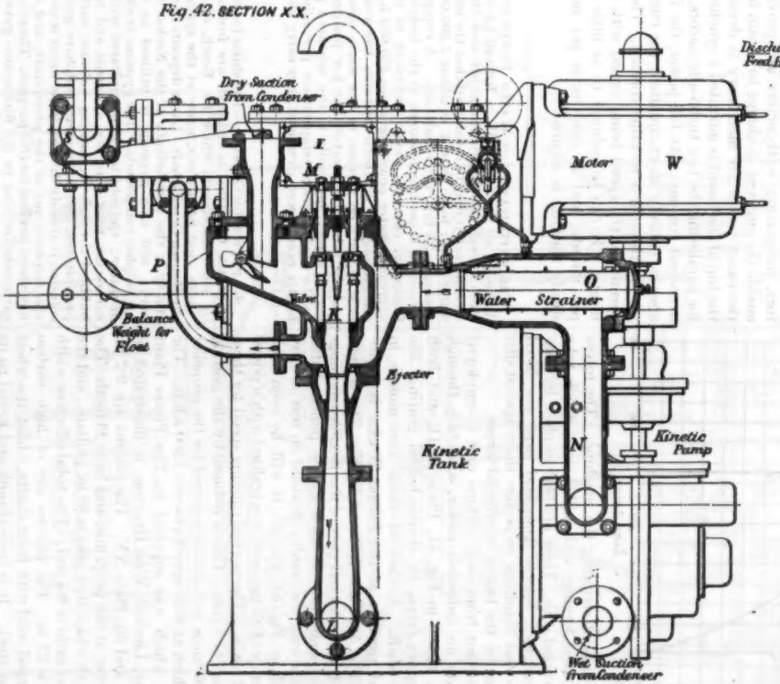


Fig. 43.

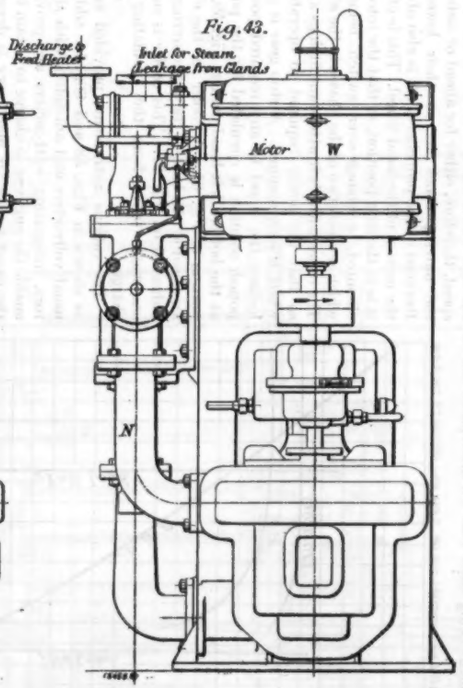


Fig. 45.

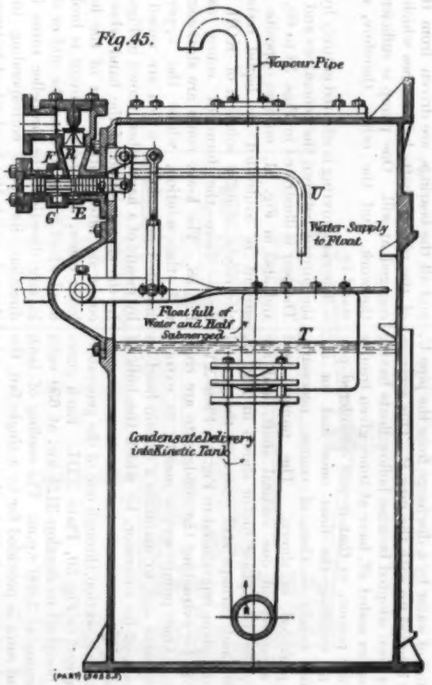


Fig. 44.

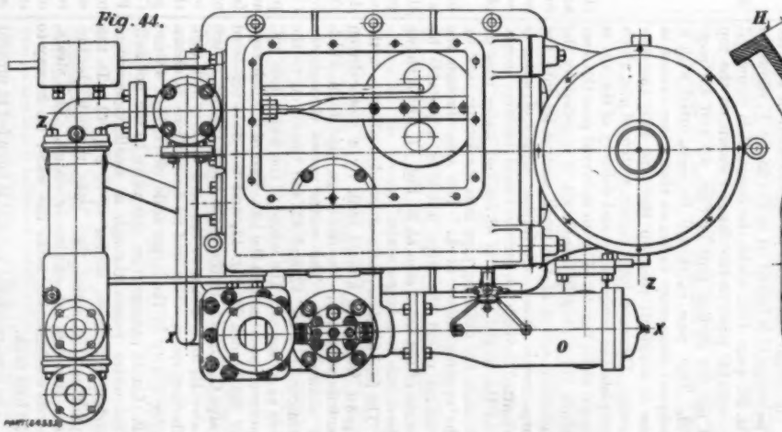


Fig. 46.

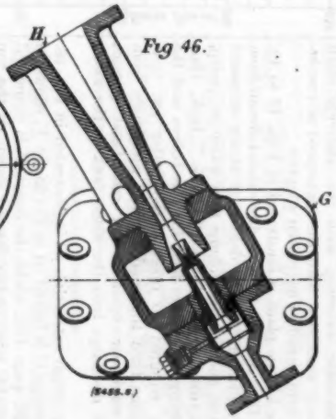


Fig. 47.

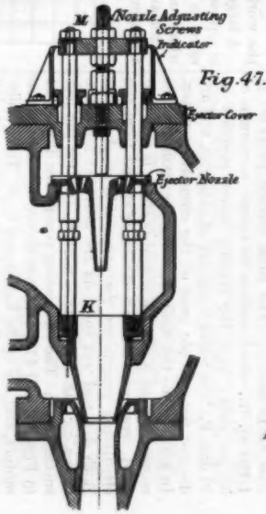
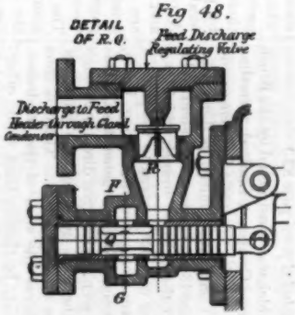
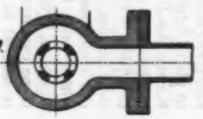


Fig. 48.



SECTION F.G.

Fig. 49.



THE LJUNGSTRÖM TURBO-ELECTRIC SYSTEM OF SHIP PROPULSION.

(*Concluded from page* 82.)

The condenser, which was constructed by the Brush Electrical Engineering Company, Limited, according to plans furnished by the Contraflo Condenser and Kinetic Air Pump Company, Limited, is illustrated in Figs. 36 to 39, page 138. It has a mild-steel body, to which is riveted the exhaust branch which is a steel casting. Other castings secured to the sides of the condenser, form rests for the spring boxes, which take the weight of the generators. This weight is, it will be seen, transferred directly through these castings to the feet, by which the condenser is secured in place on ship board. There is thus no tendency to distort the shell of the condenser, which can accordingly be thinner than would otherwise be necessary. The tube surface provided is 1,150 sq. ft., which suffices to ensure a vacuum of 95 per cent., with the cooling water supplied at 70 deg. F. The water boxes are of cast-iron, and are devised for a triple pass of the circulating water. In addition to the main inlet for the cooling water represented at A, an additional opening is provided at B, from which water can be admitted from the circulating pumps on the other side of the ship. Both dry and wet suctions are provided for. The flange for the dry suction is at F, and for the wet suction at E. The circulating pumps are illustrated in Figs. 40 and 41. They are driven by three-phase motors, and are of the high-speed type. To combine the requisite waterway with the relatively small diameter associated with the high-speed of revolution, twin impellers have been adopted.

The kinetic plant is illustrated in Figs. 42 to 49, page 139. A steam jet is used to extract the air from the condenser, and to deliver it at an increased pressure and smaller volume to a water jet pump, which discharges into a "kinetic" tank, thus supplying both the feed for the boilers and the water required to operate the water jet. At the same time the condensate is withdrawn from the condenser by a set of centrifugal pumps, which discharge into the same tank as the water jet.

The steam extraction jet is illustrated in Fig. 46. The flange G is bolted on to the flange F, shown in Fig. 36, page 138, whilst the flange H is connected by suitable pipes to the flange I shown on the top of the dry suction pipe in Figs. 42 and 43, page 139. This pipe is, it will be seen, fitted with a balanced non-return valve, so that water cannot in case of accident, pass up the pipe into the condenser. The water jet or rather, system of jets, which complete the compression and delivery of the air, is shown at K, Fig. 42. The air delivered past the non-return valve already mentioned, is impelled by the inductive action of the small central jet into the large nozzle shown. A further supply of water is admitted through the annulus round this large nozzle, and the mixed contents of air and water pass on through the diffusing pipe into the kinetic tank by the opening shown at L. The area through the annulus round the large nozzle is adjustable by means of the screw seen at M, Fig. 47, which shows the details to a larger scale.

The feed for the system of jets described is withdrawn from the kinetic tank by a motor-driven centrifugal pump, the discharge pipe from which is shown at N. The water passes through the strainer O, Figs. 42 and 43, and thence on to the jets as indicated. The whole of the water does not, however, pass through the jets. Part of it is delivered by the branch P, Fig. 42, and the float regulated valve Q, Fig. 45, to the space below the non-return valve R, and thence to the feed tank or hot well. The non-return valve and its connections is shown more clearly in the larger scale views, Figs. 48 and 49. On its passage from this valve to the hot well, this water passes through a small independent surface condenser, shown at S, Fig. 42. To this condenser the steam that leaks through the turbine glands is led, as already stated. This steam, by its condensation heats the water on its way to the feed tank.

The float-regulated valve Q is intended to prevent the possibility of the water level in the kinetic tank falling below the inlet to the kinetic pump. Should this limit be approached, the falling float moves over the valve Q, so as to cut off the flow to the feed tank. The float T is hollow, and is kept constantly full of water by a discharge from the pipe U, which is coupled up with the pipe P. This arrangement has been adopted because hollow floats having their interiors sealed off, have at times given trouble by proving porous, so that it was considered preferable to waterlog the float once and for all. A counter weight is then, of course, necessary, and is provided as shown. The pumps used are all arranged on one vertical shaft, and are driven by the three-phase motor shown in Fig. 42, page 139, and perhaps still better in the general view of the plant reproduced in Fig. 57, Plate XVI. The pumps for extracting the condensate are compounded. One pump serves merely to extract the condensate and to maintain a certain head on the suction of its successor, by which the bulk of the work is done.

A large scale section through one of the generators is represented in Fig. 50, Plate XIII. Each generator is designed to develop 312½ kw. at 650 volts when running at 3,600 r.p.m. The cooling of both stator and rotor is provided for by a single fan, the arrangement being such that all interspaces can be cleaned without stripping the machine. The rotors are solid steel forgings with milled slots, which take former-wound coils. These are held in place by gunmetal wedges. Special gunmetal caps are fitted over the end windings to secure them against displacement by the heavy centrifugal forces.

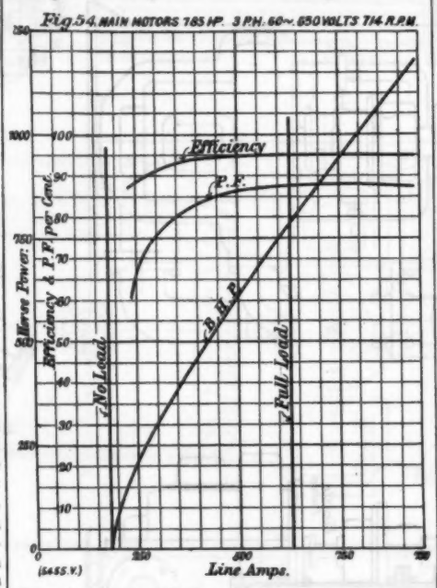


Fig. 54. MAIN MOTORS 785 HP. 3 PH. 60~. 650 VOLTS 714 R.P.M.

The current from each turbine unit is employed to actuate an induction motor, a section through which is shown in Fig. 51, Plate XIII, and both these motors drive, by double-helical gearing, the propeller shaft. A view of these two motors in course of erection at the Falcon Works, is reproduced in Fig. 52, Plate XIV, whilst Fig. 53 is a view showing the stators and part of the flexible couplings by which connection is made to the pinion shafts. Curves showing the results obtained on test are reproduced in Fig. 54, above. It will be seen that an efficiency of 95 per cent. was realised with a power factor of .875. The normal running speed for these motors is 714 r.p.m. This is reduced by the gearing to the 76 turns per minute required for the propeller shaft, which at this speed absorbs 1500 s.h.p. The gearing, which was supplied by The Power Plant Company, Limited, West Drayton, is illustrated in Figs. 55 and 56, Plate XV. The pinions are 9·2 in. in diameter at the pitch line, and have 23 teeth. The wheel with which they gear is 86 in. in diam., and the reduction ratio is 9·4 to 1. The total effective width of face is 22 in. The pinions are of high carbon steel, forged solid with their shafts, whilst the wheel is of cast-steel. It is both shrunk and keyed to its shaft. The bearings are of cast-iron, lined with white metal, and are forced lubricated. The thrust block is of the Michell type, with a single collar (see Fig. 56, Plate XV), and is incorporated in the gear case. The oil pumps which supply this block, the gear teeth, and all the bearings, are driven from the after end of the pinion shafts by clutches which can be disengaged at will. One pump is sufficient to do all the work, and the other, therefore, serves as a stand-by.

The manœuvring is effected entirely by controlling the current between the generators and the motors. The gear is illustrated in Figs. 58 to 60, Plate XVI, and also in Fig. 61, on the opposite page. The current is controlled by liquid resistances, the electrolyte being a solution of KOH. The electrodes have the form of cones, as shown in Fig. 58. The lower cones are stationary and filled with the solution, whilst the upper ones are mounted on spindles which are raised or lowered by means of a hand wheel shown in Figs. 59 and 60. In the stop position of the hand wheel the upper cones are lifted entirely out of the liquid in the lower cones, whereby the circuit is broken. If the hand wheel is moved from the mid or stop position in any direction, the propeller turns in a similar direction, its speed corresponding to the angle through which the hand wheel is turned. At full speed, therefore, either for ahead or astern working, the moving cones are in their lowest position. Reversal of the propeller shaft is also obtained from the motion of the hand wheel. This is effected when it is in the stop position, so that the rotors are open-circuited, a change-over switch being operated, which reverses two of the phases in the stator circuit. The cones with their attendant fittings are balanced, so that the power required to operate the hand wheel is only nominal. A stop gear is provided for locking the wheel in any required position. The potash solution is circulated by the pumps shown at the bottom left-hand corner, Fig. 59, and at the bottom of Fig. 61. A cooler for the electrolyte is arranged at the base of the manœuvring column, as indicated on Fig. 61. This cooler is supplied with sea water taken from the circulating pump discharge.

The various instruments provided are mounted as shown in Figs. 58 and 60. In addition to the usual voltmeters and ammeters with shunt regulators, integrating watt-meters are provided, which enable the engineer-in-charge to obtain in an instant the exact power his machinery is developing. On the top of the board is mounted a synchronising gear for paralleling the two turbo-alternators, and also an over-load cut out. At full power, the liquid resistance is entirely short-circuited, the current flowing wholly through a metallic contact. The apparatus permits of the speed being varied with the greatest nicety. It can be reduced to as little as one turn per minute, and at ten turns per minute quite steady running is secured.

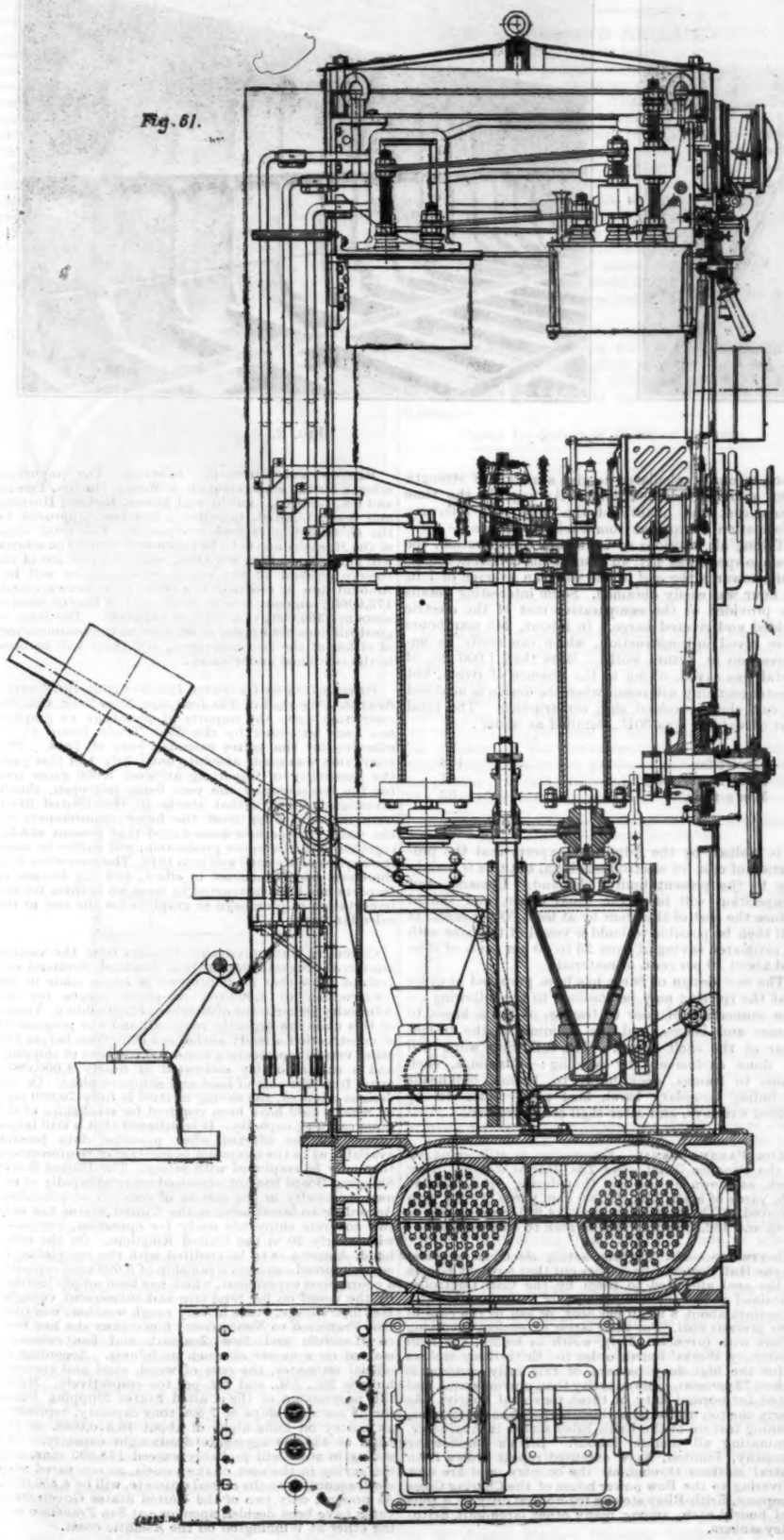
The Exploitation of Water Power in Iceland.—Although all the waterfalls in Iceland have not by any means been thoroughly examined and their capacity ascertained, it may be considered that the island possesses water power to an extent of about 2,500,000 h.p. This averages 25 h.p. per inhabitant. A company recently formed in Copenhagen known as the Iceland Waterfalls Company, controls about one-tenth of the country's aggregate water power, or some 250,000 h.p. Iceland, considering her northern latitude, has a comparatively mild climate on account of the warm oceanic currents, and the rainfall is greater than her position would lead one to expect, especially in the southern part. Owing to the high average temperature prevailing, the rivers hardly ever freeze over and they carry water throughout the year.

Sulphur from Gypsum.—The shifts for raw materials, to which Germany is reduced, are further illustrated by some statements which Dr. Bosch, of the Badische Anilin -und Sodafabrik, made at the spring meeting of the Bunsen Gesellschaft. Large deposits of gypsum occur chiefly in the Muschelkalk of the Neckar (in Württemberg), and this gypsum is utilised as raw material for sulphur compounds. The gypsum is slightly soluble in water; the solution is precipitated with ammonium carbonate, that is to say, ammonia and smoke gas are bubbled through it, causing calcium carbonate to be precipitated and ammonium sulphate gained. As the solution is already diluted, little water is used in washing the sulphate out of the precipitate, and special filters have been devised for this purpose. The crusts of calcium carbonate forming in the filters also gave trouble, but this has been overcome. In another process sulphur dioxide is bound by ammonia to bisulphite and then converted by novel reactions into sulphate.

ELECTRIC CONTROL GEAR ON THE "WULSTY CASTLE."

(*For Description, see opposite Page.*)

Fig. 61.



NORWEGIAN STATE MINING ENTERPRISE.

The Norwegian Diet sanctioned, on June 11, the purchase by the State of the important Grong "complex" of sulphur ore deposits, the purchase sum amounting to 10,593,000 kroner. The Grong mines are at present under the management of the Electrochemical Industry Company, and the more important deposits within the group in question are the Joma, the Gjersvik and the Skorovas deposits, situated east of the projected extension of the railway from Grong, through Namdale at Tunn Lake and Limingen. According to the examinations and report of Professor Vogt, the well-known expert, the Joma deposits contain 6,500,000 tons of ore, and probably considerably more; most of the ore having 44 per cent. to 45 per cent. of sulphur and very little copper; it is asserted that outside Spain and Portugal such rich deposits are not to be found in Europe. The Skorovad deposits contain at least 1,000,000 tons, almost entirely free from copper, having 50 per cent. to 51 per cent. of sulphur, and free from arsenic. The Gjersvik deposits are estimated to have a capacity of some 1,200,000 tons of ore containing 2·2 per cent. of copper and about 42 per cent. of sulphur. Thus the aggregate capacity of the Grong mines is at least 8,500,000 tons, but Professor Vogt holds that deeper working will further enhance the capacity, which he thinks will then considerably exceed 10,000,000 tons. When the transport arrangements have been adequately completed, the annual output should amount to about 400,000 tons. For this purpose the building of the Sunnan-Grong railway is essential.

The Grong mines were principally in French hands; of the shares—26,000 preference shares and 10,000 ordinary shares of a nominal value of 160 kroner each—22,500 preference shares and 3,900 ordinary shares were owned in France. Although a considerably higher price was originally asked for by the French holders, they have in the end agreed to accept 200 kroner for the preference shares and par for the ordinary shares. There is, however, a balance of 1,000 French shares, of which no firm option had been secured, but they have been put down at the same price as the bulk. The Electrochemical Industry Company obtain a materially higher price, for their shares, viz., 2,600,000 kroner—a sum of 400,000 kroner goes to the French negotiators for commission. The State purchase does not comprise some rich mines owned by the above-mentioned Norwegian company and situated in the vicinity of Skorovas, but the company has not yet been granted the necessary concession.

Prior to the purchase an Act was passed giving the State the monopoly of ore deposits in the Namdale mining districts, east of Namsen, north of Sandals, a special committee having reported to the effect, that such ores as found in the Grong deposits are almost always found in adjoining deposits, wherefore it was considered advisable to secure the monopoly for the district in question. The Norwegians have taken similar precautions on former occasion as regards silver and gold deposits in certain parts.

American Gun and Munitions Plant.—Preliminary work has been started on the new Neville Island, Pittsburgh, gun and munitions plant, to be built by the Ordnance Department, United States Steel Corporation say *The Iron Age*. Plans have been prepared for the putting down of 2,500 houses on ground near the plant, to cost from 4,000 dols. to 6,000 dols each. The number of men at work will be increased very rapidly, as plans for the building of the immense plant mature.

Tungsten Manufacture in Italy.—Subsequent to the prohibition of export of tungsten and tungsten alloys from England, French makers were allowed to supply Italy, but on terms which evidently did not satisfy the Italian consumers and Government. It is interesting to note, says *The Journal of Commerce*, Liverpool, that by the enterprise of a well-known English metallurgical firm, this unsatisfactory position has been altered, and Italy made entirely self-supporting as far as her tungsten supplies are concerned. Mr. H. A. Blackwell, chairman of George G. Blackwell, Sons and Co., Limited, of Liverpool (who are official smelters of tungsten ores to the Ministry of Munitions), arranged, with the entire concord of the Italian Government, the erection of a works and plant at San Querico, Genoa, for the manufacture by his process of ferro-tungsten and other alloys. These works are now completed and in full operation, producing large quantities of highest grade ferro-tungsten. The productive capacity of the works is in excess of the entire Italian requirements on a war basis, and the Italian Government is so satisfied with the progress made that the works were declared an auxiliary establishment by Decree of April 10, 1918, No. Min.N. 273. In addition to the manufacture of ferro-tungsten, plant has been put down for the production of various other ferro-alloys, and also all the alloys of copper and aluminium with the rarer metals. The business is operated in Italy under the name of George G. Blackwell, Sons and Co., Stabilimenti Metallurgici, with head office at Via San Luca 1-3, Genoa. The Director-General in Italy is Mr. Furio Viola, and the technical direction is in the hands of Mr. B. Hugh Rolfe, M.A.(Oxford), F.C.S., who is managing director in France of Etablissements Metallurgiques George G. Blackwell Fils and Cie., Soc. Anon, 18, Rue Laffitte, Paris, and 2, Rue d'Anvers, Laval (Mayenne). At their French company's works at Dochefort-sur-Mayenne, ferro-tungsten, ferro-molybdenum, ferro-zirconium, metallic manganese, copper alloys, &c., are produced. It is interesting to note that a British firm, in this highly technical metallurgical line, has scored such an important success by making Italy independent of foreign tungsten supplies.

AN ELECTRICALLY WELDED BARGE.

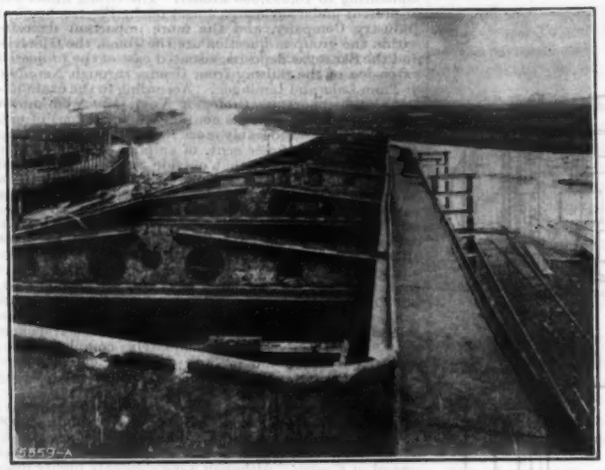


Fig. 1.

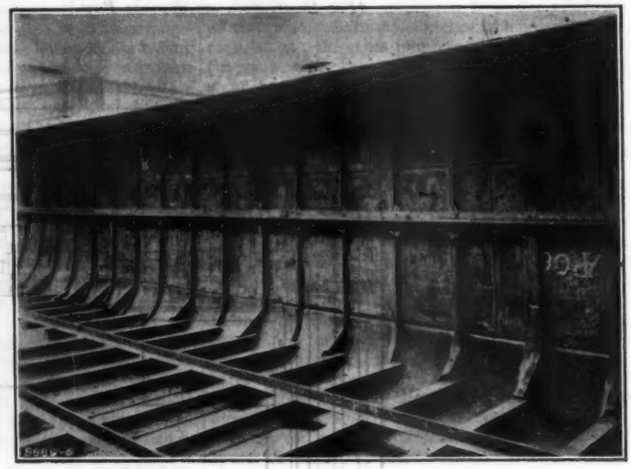


Fig. 2.

The engravings on this page illustrate a barge 120 ft. long between perpendiculars and 16 ft. beam, with a displacement of 275 tons, in the building of which no rivets were used, the whole of the structure being put together by electric welding. The efficiency of this method of ship construction has, we understand, been tested, so far as seaworthiness is concerned, the vessel, with full cargo, having been at sea during "exceptionally rough weather," and answered satisfactorily in every way to the test imposed. Great interest, therefore, centres in this departure from the ordinary system of shipbuilding, and an extension of the principle will be watched with very considerable interest. Lord Pirrie, the Controller-General of Merchant Shipbuilding, is, we understand, satisfied with the feasibility of this departure, which was carried out at a yard on the South-East Coast, under Government control. Although in larger ships it is not proposed altogether to dispense with riveting, which in certain sections is cheaper and more expeditiously effected than welding, it is intended in some future ships to combine the two systems in the most appropriate way. The United States Shipping Board have been in close touch with experimental work, and are making arrangements for the building of a number of 10,000-ton standard ships in which the use of rivets will be reduced to about 2½ per cent. of the number normally used.

The adoption of the welding process for the barge illustrated was a direct consequence of experience in welding by means of the flux-coated metal electrode process at the Admiralty Dockyards, principally in the construction of fitments, superstructures and various other parts. The component parts of the barge corresponded exactly with those of a standard riveted structure with lapped joints, because the material had been ordered before it was decided to try the welding system. The hull plates, however, were arranged for clinker build and plate edges were joggled to permit horizontal downward welding, in order to reduce the amount of overhead work, which increases the difficulty of working as compared with riveting. The hull, it will be seen, is rectangular in section amidships, with only the bilge plates curved. It was built up of 71 transverse frames with three bulkheads, those fitted fore and aft being water-tight, while the transverse amidships bulkhead was non-watertight. Quarter-inch and $\frac{5}{16}$-in. plates were used for the shell plating. Though the operatives were skilled men, with extensive experience of electric welding in the shops and minor repairs and structural repairs at shipyards, progress in the first day was poor, but with experience the speed and quality of the work greatly increased. With the more difficult welding, such as the vertical butt joints on each shell-plating, and overhead work underneath the keel and on bilge plates, it was noted that the quality of the welds was excellent. For this overhead work, special electrodes were employed and proved well worth the slightly increased cost. All water-tight joints up to and including the underside of the bilge plates, were continuously welded both inside and outside, the other watertight joints being welded continuously on one side and tack welded on the other. On the shell-plating, the continuous welding was on the outside in all cases. For internal non-watertight joints and frame construction, tack welding was adopted, the length of welding being carefully calculated to give a margin of strength over a similar riveted joint. As regards the time taken, cost and quality of the work, the following information is supplied from a reliable source:—

Taking all positions of work into consideration, the average speed was 4 ft. an hour at the commencement, while towards the end of the work an average of 7 ft. an hour was easily obtained. Some interesting details are provided of the comparative cost of the electric welded and riveted barge. In labour, 245 man-hours were saved in construction, which can easily be improved on in future work. More than 1,000 lbs. of metal was saved, owing to the absence of rivets, but greater economy will result when the design is modified to suit electric-welded ship construction. The total cost of welding was 301*l.*, detailed as under:—

	£
Electrodes	178
Electric current	61
Men's time	62
	£301

It is realised by the Admiralty experts that the proportion of cost for electrodes is high, but this is mainly due to the present limited demand. Demand and competition will have the usual effect, and should reduce the cost of this item by at least 60 per cent. It will then be possible to build a vessel of this size with an estimated saving of from 25 to 40 per cent. of time and about 10 per cent. of material.

The new design of barge has been prepared in order that the riveting may be confined to the following:—The connection of floor to frames, of beam knees to frames and beams, and the building of the frames clear of the shell seams. The following work will be done exclusively by welding:—Coamings, shell seams to frames, deck butts to beams, bulkheads (including boundary bars), keel plate butts to be welded overlays, and after shell seams welded.

The Panama Canal.—Excavation is still going on in the Panama Canal, says *The Marine Journal*, New York, as shown by the fact that during April, 278,346 cub. yards of earth and 150,000 cub. yards of rock were removed. There still remain 314,685 cub. yards of earth and 162,336 cub. yards of rock to be excavated.

Contracts.—Mr. Magoris, acting electrical engineer for the Hull Corporation, points out that a recent sample of the coal allocated to them by the Coal Controller contained no less than 30 per cent. of incombustible ash, as against about 8 to 10 per cent. of ash in the case of their pre-war coal. For their latest extension, involving boilers with furnaces 15½-ft. width as before, the Hull Electricity Works' fourth order for Erith-Riley stokers is for the high-duty pattern of this fully automatic stoker, 33 per cent. more capacity than previous ones, and suited for normal duty of three tons coal hourly. As nearly one ton will be incombustible ash, the continuous-cleaning feature of the Erith-Riley stoker is invaluable, eliminating all manual labour. Erith's engineering Company, Limited, have executed repeat orders from central stations throughout the country, and are now delivering to the Bow power house of the Charing Cross Company, Erith-Riley stokers for normal duty of 3 tons coal hourly each, among many other large-unit Erith-Riley stokers.

Ruston and Hornsby, Limited.—The important scheme for the amalgamation of Messrs. Ruston, Proctor and Co., Limited, Lincoln, and Messrs. Richard Hornsby and Sons, Limited, Grantham, has been approved by the shareholders of both companies. The total value of the Hornsby assets to be taken over under the scheme will amount to about 990,000*l.*, while the position of the reserve account of the combined companies will be: Amount now at credit of the Hornsby reserve account, 175,000*l.*; amount now at credit of the Ruston reserve account, 350,000*l.*; a total of 525,000*l.* The item of goodwill does not appear as an asset in the balance-sheet of either of the two businesses, and there will be none in the combined undertaking.

Restriction of Graphite Imports into the United States.—We read in *The Iron Age*, New York, that the restriction upon the imports of plumbago or graphite has been extended by the War Trade Board to be effective for the entire calendar year of 1918. This restriction was made absolute until July 1 of this year, the possibility of importing at most 5,000 gross tons for the remainder of the year being left open, should investigation prove that stocks in the United State were inadequate to meet the home requirements for the year. It has now been found that present stocks, together with the home production, will suffice to meet the requirements until well into 1919. The restriction has, therefore, been continued in effect, and the Bureau of Imports has been instructed to issue no licenses for the importation of plumbago or graphite for the rest of the calendar year.

Concrete Shipbuilding.—Reports from the various reinforced concrete shipyards in England, Scotland and Ireland show that good progress is being made in the construction of 1,000-ton sea-going barges for the Admiralty Department of Merchant Shipbuilding. Vessels of this class are urgently required, and the programme of construction already authorised comprises barges and other vessels representing some 200,000 tons of shipping, and a capital outlay estimated at nearly 4,000,000*l.*, apart from the cost of land and shipyard plant. On the designs adopted, the saving in steel is fully 70,000 tons on what would have been required for steel ships of the same carrying capacity. It is believed that a still larger saving will be effected when practical data become available as to the minimum proportion of reinforcement that may be employed with safety. The United States Shipping Board has not advanced quite so rapidly as our own Admiralty in the matter of concrete shipbuilding. According to latest advices the United States has only two concrete shipyards ready for operation, compared with nearly 20 in the United Kingdom. On the other hand, America is to be credited with the completion of one reinforced-concrete steamship of 5,000 tons capacity, a courageous experiment, which has been amply justified by the vessel on her trial trip and subsequent voyages. Her first voyage, made in very rough weather, was from San Francisco to Vancouver. Since then she has been to Honolulu and New Zealand, and has evidently started on a career of much usefulness. According to official estimates, the cost of wood, steel and concrete hulls is 30*l.*, 35*l.*, and 28*l.* per ton respectively. Hence the programme of the United States Shipping Board for 58 concrete ships of 7,500 tons capacity, represents an outlay on hulls alone of about 10,870,000*l.* on the basis of 435,000 aggregate deadweight capacity. The saving in steel will probably exceed 125,000 tons, and the saving in the cost of the vessels, as compared with steel, according to the official estimate, will be 4,350,000*l.* At present, only two of the United States Government yards have been decided upon, one at San Francisco and the other at Wilmington on the Atlantic coast.

THE WILD-BARFIELD ELECTRIC MUFFLE.

We illustrate in Figs. 1 and 2 herewith a portable electric muffle with pyroscopic detector manufactured under the Wild-Barfield patents, by Automatic and Electric Furnaces, Limited, 6, Old Queen-street, Westminster. This type of electric muffle is the first of its kind for use in determining the decalescent point of steel. In addition to being used in engineering establishments, it is being utilised also for the correct hardening of mine drills, for annealing various articles, &c. In the section, Fig. 2, the inner pot A is the muffle chamber, of highly refractory material; it is wound with a heating and magnetising coil B, the ends of which are connected to terminals for the electric supply on the interior cylinder. The special heat-resisting lagging is marked C, and the outside casing of the muffle is wound with a coil of special enamelled copper wire, this latter being the pyroscopic detecting coil E, which is similarly connected with terminals to the galvanometer circuit. The compensator, which is used for the purpose of balancing irregularities of voltage in the heating and magnetising circuit in order to give a clear and steady reading on the galvanometer scale, consists of a hard-

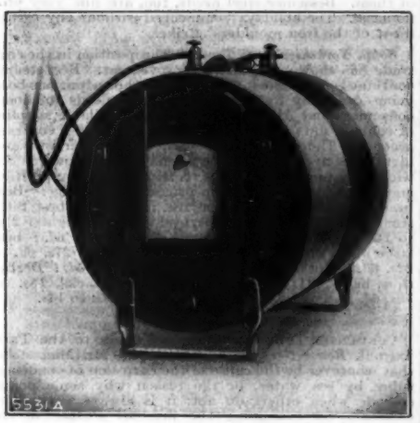
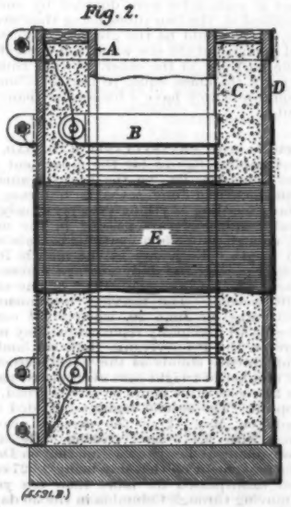


FIG. 1.

Fig. 2.



wood frame wound with primary and secondary coils of insulated copper wire connected to terminals for the electric supply, and galvanometer circuits respectively.

When a current is passed through B, the muffle becomes heated, and it magnetises any steel article placed inside it. Since the best temperature for quenching carbon steel is at its non-magnetic point, when this is reached, a small current is automatically induced in the winding E, the deflection of the galvanometer immediately notifying the operator that the best possible temperature for quenching has been attained. The best results can, therefore, always be arrived at, irrespective of the carbon content of the steel, and there is no possibility of the steel becoming overheated.

A regulating switch keeps the current within the necessary limits of heating required. The current consumption is comparatively small; for example, a muffle having an internal chamber dimension of 12 in. by 4 in. takes 1,400 watts to reach a temperature of about 1,000 deg. C. On account of the excellent heat-resisting qualities of the lagging used, the heat losses are very small.

SHIP LOSSES AND REPLACEMENT.

The official returns recently issued on ship losses and new merchant ship construction show an improvement as compared with the situation at the close of the first quarter of the present year. The losses of British ships during the second quarter amounted to 614,818 tons, whilst our output of new ships forms a total of 442,966 tons for the same period. The situation is illustrated by the diagram Fig. 1. The other diagram, Fig. 2, illustrates the world's merchant tonnage losses through enemy action and marine risk, and the world's output, also down to the second quarter of the present year. The world's output for the quarter ending June last, reached a total of 1,243,274 tons, whilst the world's losses for the same period amounted only to 946,578 tons. The output for the world during the last quarter therefore exceeded the losses from all causes by 296,696 gross tons.

The Secretary of the Admiralty this week has issued an announcement, showing the output of merchant tonnage in the United Kingdom and Allied and neutral countries during the years 1915, 1916, 1917, and the quarters ending March 31 and June 30, 1918, as follows:—

TABLE I.—*Output of Merchant Tonnage.*

Period.	United Kingdom.	Allied and Neutral.	World.
	gross tons	gross tons	gross tons
1915	650,919	551,081	1,202,000
1916	541,552	1,146,448	1,688,000
1917	1,163,474	1,774,312	2,937,786
1918			
First quarter ..	320,280	550,037	870,317
Second quarter..	442,966	800,308*	1,243,274

* Provisional figures.

In the same returns, the Secretary for the Admiralty published the tonnage of merchant vessels completed in United Kingdom yards and entered for service during July, 1918, compared with preceding periods; he remarks that the information is in an amended form, adding that the return, whilst giving practically all the information contained in the former one, will, in the opinion of the Controller-General of Merchant Shipbuilding, enable the public more readily to grasp the position. It will also be adopted in future months. The particulars are contained in the following table:—

TABLE II.—*Tonnage of Vessels Completed in United Kingdom Yards and Entered for Service.*

	Completions.		Completions.
1917	gross tons	1918	gross tons
January.. ..	48,089	January.. ..	58,568
February ..	79,451	February ..	100,038
March	118,699	March	161,674
April	80,711	April	111,533
May	99,773	May	197,274
June	109,847	June	134,159
July	83,073	July	141,948
Total 7 months to July 31, 1917	578,643	Total 7 months to July 31, 1918	905,194
Total 12 months to July 31, 1917	865,147	Total 12 months to July 31, 1918	1,490,025

With reference to the information contained in Table II., the Controller-General for Merchant Shipbuilding states that the figures for the month of July in any year are not usually very high, owing to the holidays which are taken at this time of the year, and which, having regard to the sustained strain on the men, he did not consider it wise to ask them to forego. Towards the end of June most of the shipyard workers on the English North-East Coast take their fortnight's holiday; and during July a similar state of affairs exists both on the Clyde and in Belfast. Compared with the month of July in 1916 and 1917, the output for July, 1918, shows an increase of 174 per cent. and 71 per cent. respectively.

The serious influenza epidemic has had a transient, although marked, effect on the shipbuilding industry. He received several letters from shipbuilders stating that, during the epidemic, from 35 per cent. to 50 per cent. of their workmen, draughtsmen and clerks have been absent, and although most of the men are now back at work, it will be realised that this has somewhat retarded progress all over the country.

Having regard, however, to all circumstances, he considers the July output as being reasonably satisfactory.

The above figures, satisfactory in themselves, gain much in significance from a statement recently made by Sir Joseph Maclay, Shipping Controller, to the effect that only those who have access to official records can appreciate the character of the enemy's effort to arrest the varied transport movements, and particularly the transport of the American forces destined for Europe. The enemy has been able, in the words of Sir Joseph, to combine his original purpose and his original plans for attempting to starve out England, with his new plans for attacking the transports. Every submarine at the command of the Germans has been sent to sea, manned by the most experienced officers and men, but over 1,000,000 troops, with stores complete, have been carried across the Atlantic, and the lives of less than 300 soldiers have been lost. On the average, about 60 per cent. of the American soldiers have been carried in British ships, and the proportion, Sir Joseph says, is steadily rising.

Fig. 1. LOSSES BY ENEMY ACTION AND MARINE RISKS. ALSO SHIPBUILDING OUTPUT OF THE UNITED KINGDOM

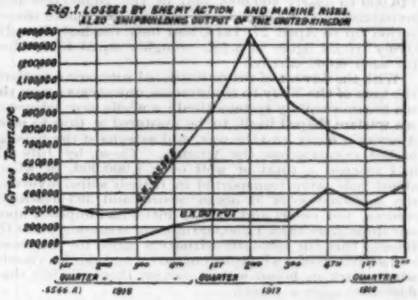
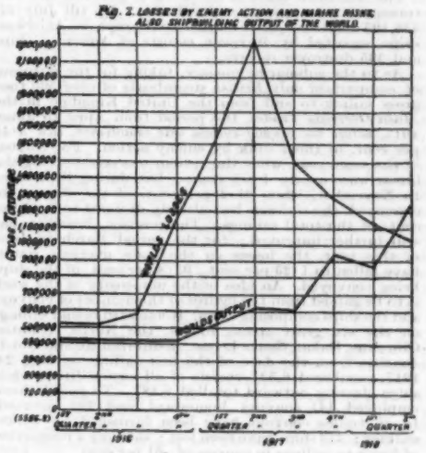


Fig. 2. LOSSES BY ENEMY ACTION AND MARINE RISKS. ALSO SHIPBUILDING OUTPUT OF THE WORLD



The fact, nevertheless, remains, he adds, that the importance of speeding-up British construction cannot be exaggerated, for the question of tonnage is becoming every day increasingly the predominant problem of the war for the Allies. All the armies, in varying degree, are drawing their strength from the sea, and the burden which they are imposing upon shipping is increasing. In this connection, the American authorities have exhibited good judgment in that they have placed the provision of ships in the forefront of their war programme. The number of American soldiers is being rapidly increased every month, and the million men will have become several millions in the next twelve months, if the war lasts as long. "As to that, no one can give any forecast," concludes the Shipping Controller, "but, at any rate, it is apparent that, as with us in the British Isles, so with the Americans, the military problem in the last analysis is a tonnage problem," a statement which is evident to the most casual observer.

EXTENSION OF THE MANNESMANN TUBE WORKS.—It is announced in the *Frankfurter Zeitung* that the Mannesmann Tube Works are about to be extended by the acquisition of the Wittener Steel Tube Works. The two businesses have already been working in close co-operation, and the Mannesmann Company owned a considerable block of the Wittener shares. The larger concern bases great hopes on the new method of making seamless tubes which is a speciality of the smaller concern. The Wittener Company has a capital of 7,500,000 marks, and after being unable to pay a dividend for five years, it paid 6 per cent. in 1916–17. The share capital of the Mannesmann Tube Works is now 86,000,000 marks. The last increase was in December, 1917, when for the purpose of acquiring the majority of the shares of the coal mine "Unser Fritz," the company issued 14,000,000 marks' worth of new shares. At the outbreak of war the dividend sank from 13½ per cent. to 7½ per cent.; it has since gone up to 10 per cent., 15 per cent. and latterly 18 per cent.

THE WORK OF THE NAVY.

The supreme task of the Navy has been to make secure on all the seas of the world the transportation of men, material and food. Between the date of the declaration of war and June 30 last, the needs of the Allies have involved the carriage by sea of some 20,000,000 men, 2,000,000 animals and about 110,000,000 tons of naval and military stores, cargoes whose vastness and diversity have never been contemplated nor foreseen. The submarine war intensified and waxed to its greatest violence, yet the great work of supply and transportation went forward with never an interruption; there was never a time when the Allied path towards the ultimate victory was closed. The Navy, which in August, 1914, had comprised warships and auxiliary vessels to a total of 2,500,000 displacement tons, had swelled by June of this year to 6,500,000; its personnel had grown from 146,000 to nearly 400,000, and of the 20,000,000 men embarked and transported, the total losses due to enemy action up to April 27, 1918, had only reached the relatively trivial figure of 3,282—roughly equal to one lost for each 6,000 carried.

With the advent of the unrestricted submarine warfare, the task of the Navy to secure communications across the sea became rapidly systematised; a whole new science of sea warfare shaped itself, to be mastered in time to meet America's entry into the war, and safeguard the passage of her troops across the Atlantic. These, by July 27, had reached a total of well over 1,000,000, of whom about half were transported in British ships, involving the organisation of 51 ocean escorts and 393 destroyer escorts, and escort and convoy duties had imposed upon our ships more than 1,250,000 miles of steaming a month. Besides this, the submarine situation called for the ceaseless activities of a whole fleet of patrol and similar vessels, whose work in home waters carries them not less than 6,000,000 miles a month.

The American share in the work of guarding her own transports was prompt and valuable. Up till July 27, 556,195 men had been ferried to Europe in American ships, escorted by 40 ocean escorts of American ships and 335 destroyer escorts.

As to the submarine menace, taking for the purposes of comparison only *British* steamboats of over 500 tons gross sailing to and from the United Kingdom in the *Main Overseas Trades*, the period from April to June, 1917, *before the convoy system was established*, saw 5·41 per cent. of them sunk by enemy action. For August of the same year, when the system was commencing the losses were nearly 4 per cent.; but during September to November, when 91·2 per cent. of the ships were convoyed, the sinkings had already dropped to 2·11 per cent. of the total sailings. The position, however, has still further improved; for the period March to June of this year, the losses on the main overseas routes have fallen to 1·23 per cent., 93·8 per cent. of the ships being convoyed. An idea of the immensity of the work is to be gained from the figures of the number of convoys and the ships composing them. Homeward bound sailings on the six great steam routes, the North Atlantic, Gibraltar, Dakar, Sierra Leone, Mediterranean and Rio de Janeiro, from the date of the first sailing on May 24, 1917, numbered 6,521 vessels of all nationalities, while ships clearing outward totalled 5,487. To guard them, employed 441 convoys homeward and 392 outward. In *all* trades convoys have been furnished for 61,691 sailings; 373 ships have been lost; showing a proportion of losses to sailings in convoy of ·61 per cent.

The Internal-Combustion Engine in Navigation.—Speaking at the annual general meeting of the "Shell" Transport and Trading Company, Limited, held on Tuesday, July 30, in London, Sir Marcus Samuel, Bart., the chairman of the company, said he viewed with misgiving the creation in this country of a large fleet of standard ships constructed to run on steam engines, because he felt sure that they could not compete with ships driven by internal-combustion engines. These latter engines were being manufactured on a gigantic scale by Germany, the United States, Denmark, Holland and Sweden. He hoped his friend, Lord Pirrie, who had successfully built internal-combustion engines, would give the greatest heed to this important question. At all events, the "Shell" Company was determined to provide oil stations wherever they were required, feeling quite confident that the future would develop more and more the need for oil. Placed as the company's fields were throughout the world, the company was in a position to meet the requirements for oil probably better than any other company or combination.

American Shipbuilding.—The following telegrams exchanged between Mr. Hurley, chairman of the American Shipping Board, and the Shipping Controller, are forwarded for publication:—"I know you will be glad to learn that American Shipbuilders have again broken all records in launching at Alameda Shipyard, California, the 12,000-ton cargo steamer Invincible, built in 24 working days. A liberty job from start to finish, as the keel was laid on July 4, five seconds after the launching of the sister ship Defiance, built in 40 working days. The Invincible will be under steam 35 days after launching. Merchant Shipyard launched the first hull on the 5th inst., and Hog Island will launch the first hull on the 12th inst., thus putting into production all four Great Eastern Fabricated Shipyards. We are determined to match the American military force with tonnage."—Signed, Hurley.—"Congratulate you heartily on magnificent accomplishment which is further guarantee of defeat of submarine. We rejoice in the absolute assurance that American military effort, vast though it is, will not be hampered by lack of tonnage." Signed Maclay

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—Throughout the entire West of Scotland area, the greatest activity prevails, the orders booked during the holidays alone being sufficient to keep every mill occupied for the next six months at least. Some little difficulty exists in connection with the coal supply which has been further curtailed as the result of the recent "comb-out" in the Scottish mines, and unless a satisfactory solution can be arrived at, steel-makers will be unable to maintain the present heavy output. Sectional material and plates for the shipbuilding yards are in constant demand, for the Government's contracts are important and pressing, using up the bulk of the tonnage produced, both naval and mercantile construction coming under the category. In addition, work of national importance goes on in every direction, and the demand is being as well met as could possibly be desired. Home consumers are being supplied in much better fashion, and some small shipments to France and India have been sanctioned. No change in price has been reported.

Malleable Iron Trade.—Work in the malleable-iron trade proceeds apace, and plants are being run to their fullest capacity. Everything produced is quickly absorbed on war account, small rounds and light rails being much in demand in the home markets. Very little export is being put through, although the price for "Crown" bars stands at something like 16*l.* 5*s.* per ton and upwards—the needs of the home consumer, however, are pressing.

Scotch Pig-Iron Trade.—Pig iron continues in excessive demand, hematite, particularly, being much wanted and very scarce, while better supplies of forge quality are now available. The home needs, being of national importance, must be met, and in consequence the export trade is at a complete standstill, despite the efforts of the smelters during the holidays and the firm prices now ruling. Labour is scarce, however, and transport facilities have not yet improved to any appreciable extent, so that overseas consumers must just forego their claims to consideration in the meantime. The Allied Governments are permitted a certain percentage of the output, but by far the larger proportion is retained at home.

Scottish Ironmoulders.—At a recent meeting of the Committee on Production, when an increase of wages was granted to the Scottish ironmoulders, it has transpired that there was no representation of the National Light Castings Ironfounders' Federation, owing, it is asserted, to the notice not having been issued in time. The matter has been taken up with some spirit, and the offer of the Committee on Production to meet the representatives of the men, and to allow the Employers' Federation to state their views should they desire to do so, on August 13, has been rejected. In order that the award may be operative from August 10, the date of the previous award, the men's representatives request an earlier hearing, threatening "grave consequences" if this should not be acceded to.

Honours to Naval Engineers, &c.—The following Honours have, with the approval of His Majesty the King, been conferred upon naval engineers, among others:—For services in action with enemy light cruisers: To receive the D.S.M., Chief Engine-room Artificer G. H. Routley. Mentioned in Despatches: Engineer-Lieut.-Cdrs. W. H. Cleghorn, R.N., and S. Brown, R.N. For services in action with enemy submarines: To receive the D.S.C., Engineer-Lieut. E. Jones, R.N.R. To receive the D.S.M., Chief Engine-room Artificer A. Tatham. Mentioned in despatches, Artificer-Engineer Walter Lee. For services in Mesopotamia and the Persian Gulf: Mentioned in Despatches, Engineer-Cdr. F. B. O'Dogherty, R.N., Engineer-Lieut. C. R. L. Bergner, R.N., Chief Engine-room Artificers J. K. Bowden, T. Roe, A. Skyrme, Engine-room Artificer W. J. Chapman. Honours for the Mercantile Marine: To receive the D.S.C., Chief Engineers A. Allan, T. Boleyn and G. Gemmell. Commended for services: Chief Engineers A. Ayres, F. Dring, F. Graham, G. Hughes, H. M. A. London, R. Milligan, 2nd Engineers A. Crawford and J. Kane, 3rd Engineers A. Anderson and W. F. Hardy.

The Royal Indian Marine.—The Secretary of State for India makes the following announcement regarding the Royal Indian Marine:—(i) Certain improvements have recently been made in the pay and prospects of the service, and also in the grades and designations of officers; (ii) A Selection Board has been appointed to consider all applications for permanent appointment, both to the executive and to the Engineering branches of the service. All candidates must be the sons either of natural born or naturalised British subjects. The minimum and maximum age limits remain as before, viz., 17 and 22 for the Executive, and 21 and 25 for the Engineering branch. A candidate for the Executive branch is not required to possess a Board of Trade certificate (second mate), but must produce in lieu thereof evidence of four years' service at sea, or a course in a training ship with subsequent service at sea, amounting to four years in all. A select candidate who does not possess the certificate will be appointed on probation for 18 months in the first instance. A candidate for the engineering branch who does not possess a Board of Trade certificate of competency as first or second class engineer, may be appointed as assistant engineer on probation for 18 months in the first instance. Candidates will be required to appear before the Selection Board and will also be examined by a Medical Board as to their physical fitness. Further particulars under both the above heads and forms of application for appointment may be obtained from the Secretary, Military Department, India Office, London, S.W.1.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

The Holidays.—Practically the whole of the local industries are at a standstill. In most of the works, operations were suspended on Friday evening, and there will not be a general resumption before the beginning of next week. This is the first time since the beginning of the war that there has been such a lengthy, and so complete a stoppage, but in many respects, the respite is most opportune. It was rendered the easier by the dwindling tendency, which has existed in trade for some time past. To the workers, the holiday affords a timely relief, and it will facilitate greatly needed repairs of plant and machinery.

Iron and Steel.—The week preceding the holidays was one of the quietest war-time periods yet experienced in the iron and steel industry. The departments where anything like marked activity could be seen were very few indeed. One of these was the open hearth steel trade. The demand for this class of steel in the crude state was very difficult to satisfy, and this, despite the ever-expanding productive capacity of the industry. The munitions factories have been keeping up a sharp pressure for steel. High-speed steel has been somewhat urgently requested, but not in anything like the volume of past months. At the crucible steel furnaces, the conditions were so slack that short time was being worked at some of them. Bessemer steel needs, too, are not very pronounced. The holidays commenced without any settlement of the iron moulders' strike.

South Yorkshire Coal Trade.—The position in the coal trade has shown very little improvement. Best steams continue to be in great demand, and the output has been going away day by day to satisfy the needs of home consumers and Allied countries. All available supplies of cobbles, nuts and slacks are absorbed under contract account. The scarcity of household sorts persists, and merchants are quite unable to make any provision for winter consumption. Cokes remain in a strong position and readily bring maximum prices. Quotations:—Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

Condenser Tube Corrosion.—Writing to the Paris journal, *Revue Générale de l'Electricité*, Mr. Miet states that whatever be the cause of the corrosion of condenser tubes by sea water, or the reason why some points corrode when others do not, it is always possible to ascertain by examining the internal surface of the damaged tube, that the corroded parts, as a whole, form but a very low proportion of the total area of the tube exposed to sea-water action. It would seem, therefore, that if each tube were doubled by another tube placed around it, the two tubes being then drawn down together, there would be the greatest chances that the corroded portions of the one would not coincide with the corrodible portions of the other. A tube thus doubled, but having a thickness equal to that of a single drawn tube, would probably have a longer life than the latter, single tube.

Traffic on the Pennsylvania Railroad, Eastern Lines.—Complete figures for the movement of freight cars past Columbia, Pa., on the Pennsylvania Railroad during the month of June, reveal an immense volume of traffic, far exceeding anything ever previously recorded. The total number of cars passing in the month was 250,322, enough to make a continuous train over 2,000 miles in length. Each day in the month 70 miles of freight cars passed, the daily average movement being 8,344 cars, which is the equivalent of one car passing every 10 seconds. The heaviest movement for any single day was on June 20, when 9,531 cars passed. This exceeds all previously reported one-day movements anywhere on the Pennsylvania Railroad, and, in addition, undoubtedly stands as the world's record for the greatest number of freight cars ever moved past a given point in 24 consecutive hours on any railroad, American or European. The second highest recorded movement was made on May 12 of the present year, also at Columbia, with 9,173 cars passing. The third best record was made at Lewistown Junction on December 7, 1907, the movement on that day being 9,027 cars. This remained unsurpassed for more than ten years. The freight moving through Columbia in the 30 days of June exceeded 6,000,000 tons, or more than 1,200 ordinary steamship cargoes of 5,000 tons each. Roughly, 40 vessel loads of freight a day were hauled past this point during the month. Of the 250,322 cars moving past Columbia in June, 138,532 were loaded and 111,790 were empty. An overwhelming proportion of the traffic recorded was of the most essential character for the successful prosecution of the war. It consisted in very large part of the iron and steel products of the Pittsburgh industrial region, coal from the mountains in central Pennsylvania and coke from the many ovens in the same region. Included were ship plates and other necessary material for shipbuilding in the tidewater yards, supplied for the building of new shipyards and other war industrial plants, raw and semi-finished materials to keep the eastern munition plants in full operation, and fuel for the eastern industries and for the ships which are keeping up the vital line of communication with Europe. The heaviest tonnage of these classes of freight converges upon the Pennsylvania Railroad, east of Pittsburgh, and must necessarily be given preference over commercial and all other less essential traffic.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig iron is on a fairly large scale, notwithstanding that home consumption in August will be less than in recent months, in consequence of annual holidays. Traders have arranged most deliveries of foundry iron under the allocations, and shipments of this quality to the Allies are understood to be proceeding steadily; whilst licenses for some small parcels to neutrals have been granted under special circumstances. Irregular working of furnaces, due to the situation as regards coke, is resulting in output of more forge iron, and with this description quite plentiful, it is offered freely on both early and forward account. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge were all quoted 95*s.*, and No. 1 is 99*s.*; whilst for export to the Allies, No. 3 and the lower qualities are 119*s.*; and No. 1 is 124*s.*

Hematite Iron.—Little new is ascertainable concerning the East Coast hematite branch of industry. Output is maintained on a sufficient scale to meet all essential home requirements, but the quantities of iron available for export are small. Most of the shipments are for France through official channels. The decision to carry on trade with Italy in a similar manner is criticised by merchants, who claim that they have built up connection over a long period, and they fear that prospects of recovering their markets after the war are not over bright. Representations are being made to the Authorities to this effect in the hope that arrangements will be made whereby firms will be enabled to retain their foreign trade. Notwithstanding other advances, the price of Nos. 1, 2 and 3 East Coast hematite remains at 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for shipment to France and Italy.

Manufactured Iron and Steel.—Producers of finished iron, and steel, though hampered by scarcity of labour, and fuel, keep very busy. Output has certainly been curtailed, but it is still on an enormous scale. Manufacturers are well ahead with shipbuilding needs, and, as a result, are able to deal rather better with the considerable arrears of other classes of work. Advances in iron bars are reported, and principal market quotations to home customers now stand: Common iron bars, 14*l.* 15*s.*; best bars, 15*l.* 15*s.*; best best bars, 16*l.* 15*s.*; best best best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*—all net. There are no fixed quotations for export, but they may be given as, approximately, 2*l.* to 3*l.* above home prices.

Shipments of Iron and Steel.—Last month's shipments of pig-iron from the port of Middlesbrough constitute a record so far this year, but the aggregate of pig-iron, manufactured iron and steel shows a decrease on the total June clearances. The July loadings of pig-iron reached 49,110 tons—an increase of 5,063 tons on the June returns; and nearly double the March shipments of 25,950 tons, which were the lowest clearances this year. Of the pig-iron despatched last month, 41,439 tons went to foreign ports, as against 37,841 tons in June; and 7,671 tons went coastwise, as against 6,206 tons in June. Last month's shipments of manufactured iron and steel amounted, in the aggregate, to 7,756 tons, compared with 16,328 tons in June. Of the July clearances, 5,127 tons went abroad, and 2,629 tons went coastwise, 372 tons being manufactured iron, and 7,384 tons steel. Thus, the total shipments of pig-iron, manufactured iron, and steel for July amounted to 56,866 tons, as compared with 60,375 tons in the preceding month, and 39,343 tons in May.

Coke.—The situation as regards coke is really serious. Many expedients are resorted to, in the endeavour to cope with essential needs, but supply is inadequate, and is from hand to mouth. As a result of the shortage some of the blast-furnaces have had to be put on slack blast. Medium furnace quality is quoted 33*s.* at the ovens; and low phosphorus sort, 35*s.* 6*d.* at the ovens. Demand for neutrals is very keen, and 65*s.* is offered for good foundry coke, but such business is practically impossible with the supply taken up in other directions.

HYDRO-ELECTRIC SCHEME FOR KOBÉ.—The municipal authorities of Kobé, says *The London and China Telegraph*, contemplate undertaking a hydro-electric enterprise, and have been looking for a suitable source of power. It is now reported that they have found one on a section of the Chigari, on the upper reaches of the Muko River, about 20 miles away from Kobé. It will be remembered that on the Chigari a new water-reservoir has been recently built. Mr. Kobori, director of the Electric Bureau in the Kobé City office, says the site selected is a very suitable one, and application for permission to use the river will be shortly made to the proper authorities. The selected site is conveniently situated in the neighbourhood of the municipal reservoir, and since operations can be carried out jointly with the waterworks, it is believed that the cost of undertaking the hydro-electric enterprise will be considerably economised. It is proposed to obtain about 5,000 kw. on an average, with a maximum capacity of 10,000 kw., and it is estimated that the undertaking will cost about 3,500,000 yen. When the proposed enterprise has materialised, it will be possible to supply Kobé with about one-third of its present supply of current. Mr. Kobori adds, however, that it will not be possible to lower the charges for current either for electric light or other purposes.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Consequent upon the miners taking three days' holiday this week, the shortage of coal has become more pronounced than ever. The local coal markets were closed on Monday and Tuesday, and were only open till noon to-day. There were only a comparatively few members in attendance, it being futile to attempt to do business under the circumstances. All the coal was taken up officially, and it is announced by the South Wales and Monmouthshire Coal and Coke Supply Committee that for the next ten days there will be no house coal available. Arrangements have now been completed for the working of the new Shipping and Coal Co-ordinating Committee. Individual returns received every Saturday by the secretary of the Committee for the Supply of Coal to France and Italy, are summarised and forwarded to the secretary of the new Co-ordinating Committee, to whom exporters and shippers have also to furnish particulars regarding any subsequent changes in the position of vessels. By the adoption of this method it is anticipated that a considerable amount of delay will be obviated. For the moment, the markets are otherwise featureless, and prices remain unaltered.

Newport.—There was no business done in Monmouthshire coals when the market re-opened this morning. In view of the miners' holidays, and the consequent restricted outputs this week, all classes of coals were last week taken up by the authorities. There were plenty of inquiries to-day, but there was literally not a ton to spare. The position is reacting on the supply of coke and especially of patent fuel, the production of which are by no means equal to the demand. There is a fair amount of pitwood arriving, and in certain cases advantage is being taken to store up as much as possible in view of the possibility of the supplies not being so plentiful later on.

Prevention of Absenteeism at Mines.—Although no publicity has yet been given to the matter, the details of the proposed Joint Pit Committee's agreement have been privately circulated. The functions of these Committees, the principle governing which was agreed upon between the Miners' Federation and the Coal Controller, are to be directed towards "decreasing voluntary absenteeism and increasing output." Clause 75 of the agreement is the principal feature and this is as follows:—"The management of collieries shall supply the Committee weekly with particulars showing the average output per man in the case of coal-getters, and also the average output per person employed in and about the mine, commencing with the week comprising the last pay day before Sunday, June 30. The Committee will investigate cases of declining output, and consider to what extent the cause is due to more difficult physical conditions in the seam or altered physical or mechanical conditions in haulage roads or to any other cause whether personal to the getter or other worker, or to the management or not. Where the output is less than could be reasonably expected, having regard to all the circumstances, the Committee will interview the management or workmen or both with a view to an improvement." It will be noted that although the management of colliery managements have to be parties to the scheme, they have not been consulted, and the South Wales Coalowners' Association have withheld their assent to the scheme pending further consideration.

Restive Colliery Examiners.—The lower grade colliery officials who are members of the South Wales Colliery Examiners' Association are still dissatisfied, and have not yet accepted the owners' proposals for a final agreement setting forth conditions of employment. A conference of delegates representing these officials was held at Cardiff, on Saturday, and the resolution which was adopted indicates the feeling which prevailed. "We are astounded"—so runs the resolution—"that there is yet a difference of over 8*s.* weekly between the coalowners' offer and what we considered to be a most reasonable wage claim. Their effort to perpetuate a difference in the wages of one section and another cannot be tolerated. To take away any of the privileges at present in existence we regard as most unreasonable, and we press our claim to the very serious consideration of the owners' side of the board, and urge upon them to place our members on a basis equal to the responsibilities which they have to face every day."

MERCANTILE MARINE SEAMEN.—The Board of Trade and the Shipping Controller are arranging for the compilation of a complete register of all masters, apprentices and seamen (that is all seafaring officers and men), so that an effective comparison may be made between the present supply and the demand which may be anticipated in the near future. The opportunity of this registration will be taken to furnish each man with an identity and service certificate, which, after being endorsed by the National Service Ministry, will be a protection from recruitment, so long as the holder fulfils the conditions of his employment in the Mercantile Marine. The identity and service certificate is to be produced by the man whenever he is engaged for service afloat, and will at first only be issued to *bona fide* sea-going men. The scheme will be worked in close conjunction with the principal Unions and Associations of the Mercantile Marine, on whose cordial co-operation the Board of Trade and the Shipping Controller confidently rely. In future, account is to be taken of the actual sea service of every seaman, and it will be a condition of his protection from recruitment that he serves afloat for a minimum number of days every year, due allowance being made for exceptional circumstances.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 10, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The annual general meeting will be held. The following paper will be open for discussion:—"Notes on the Overhead Kœpe Winding Plant at Plenmeller Colliery, Haltwhistle, Northumberland," by Mr. George Raw. The following paper will be read or taken as read:—"Record of Gas Pressure from a Borehole," by Mr. Charles J. Fairbrother.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, August 13, at 7 p.m., at the Mining Institute, Neville Street, Newcastle-upon-Tyne. "The Manufacture of Cast Iron Pipes," by Mr. T. E. Dimbleby.

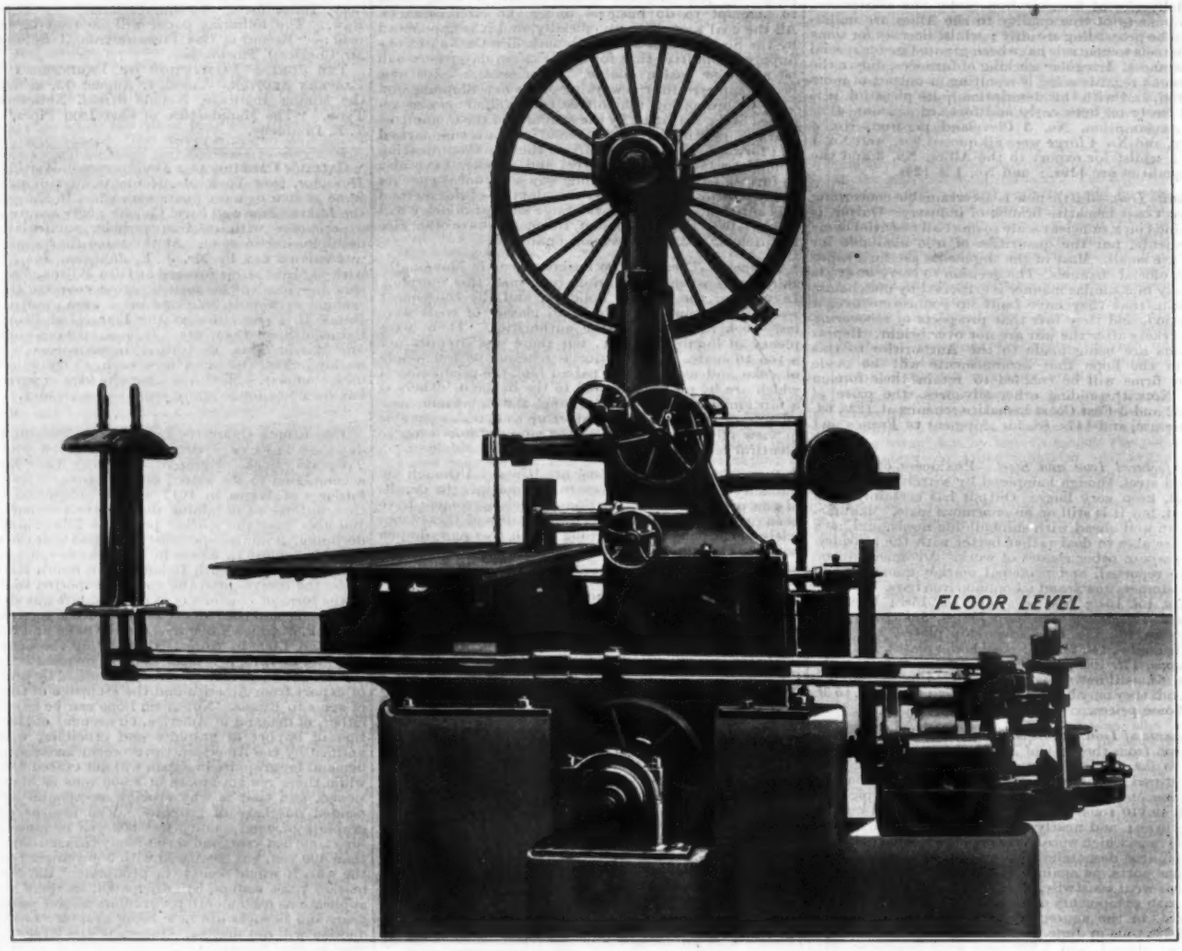
CALCIUM CARBIDE AS A DEOXIDISER.—Writing in *The Iron Age*, New York, Mr. Henry G. Martin states that some twelve or more years ago, when in the service of the Lukens Iron and Steel Co., he made some extended experiments with calcium carbide, particularly as a desulphuriser in steel. At the same time similar work was carried out by Mr. J. E. Johnson, Jun., working with pig-iron at his furnace at Glen Wilton, Va., Some time previous to this letters patent covering the use of calcium carbide in iron and steel were granted to Mr. Frank E. Parks, then at the Planestead Plant of the Carnegie Steel Company. It is a striking coincidence Mr. Martin adds, that three investigators were thus working along the same lines, each in ignorance of the others' efforts. Moreover, that the idea apparently has lain dormant for so many years seems strange.

THE KOREA GRAPHITE INDUSTRY.—According to the Japanese Press, as reported in *The London and China Telegraph*, stocks of graphite at Pyeng-Yang have now accumulated to the extent of 2,000 tons. The graphite business of Korea in 1917 was so prosperous that all those interested in mining devoted their attention to it. But this year the market price has fallen, and is still declining. A mining specialist has stated that the production of graphite in Korea in 1917 was as much as 6,500 tons, North and South Heian-do and South Kankyo-do being the centres, and the amount exported to America in the form of crucibles or as raw graphite was altogether 4,500 tons, and the balance of about 2,000 tons remained in stock, of which 1,000 tons are in Osaka and Sinmonoseki, and 1,000 in Korea. Considering the demand for graphite in 1918, it is clear that the demand is not what it was in 1917, owing to lack of iron caused by prohibition of export from America and the stoppage of the supply of arms to Russia. Not much hope can be entertained, either, of demand in America, on account of the restriction of import of graphite and crucibles, which was notified by the American Government last winter. The demand for graphite in Japan will not exceed 3,000 tons, while there remain stocks of 2,000 tons as above mentioned, and that is why crucible companies have suspended purchase of graphite. The market price for graphite of good quality was 600 yen or more per ton for a time last year, and seems likely to come down to less than 400 yen, but compared with 300 yen per ton before the war, it would seem to be profitable. But the future market price cannot be anticipated, as there were 300 applications each month for graphite mining permits last year, and licences are now being granted, so that production will not decline. Owners of the larger mines at Shin-an-shu, Sensen and Jo-shin are aiming at quality and reducing production.

FUEL ECONOMY.—Owing to the large number of miners called to the colours, and the great need of coal for our Allies, the various Government Departments and industrial undertakings, the Controller of Coal Mines has instituted a coal economy campaign with the object of reducing fuel consumption in every direction possible. The Controller is being assisted by a technical staff attached to the head office, and arrangements have now been made for a large number of engineers in the provinces to attach themselves to the Coal Control Department for this special purpose. This arrangement enables the country to be mapped out in districts, so that all industrial consumers will, within a reasonable time, be in touch with the organisation. The scheme comprises two main sections, viz.:—1. Electrical undertakings; 2. industrial undertakings. The work involved includes the careful scrutiny of the quantity and quality of coal consumed by the various undertakings and the efficiency obtained. It also includes the inspection of factories and works by experts, in order to ascertain means by which fuel consumption may be reduced, and the best methods to that end. A considerable amount of work in connection with the campaign has already been done, but it is intended to accelerate the rate of progress as much as circumstances will admit. Some 400 skilled engineers will shortly be at work in various parts of the British Isles, and these gentlemen are giving their services to the Government without salary. Any public body or company or person wishing to effect economies at once, and desiring the Controller's assistance in this direction, is invited to communicate with Coal Control Headquarters, Room 309, Holborn Viaduct Hotel, London, E.C.1, when arrangements will be made to send a technical expert to look into the conditions under which coal is being consumed, and to co-operate with the consumer in effecting economy. Apart from special applications of this kind, the Controller's representatives will visit firms in turn, in accordance with a general plan of operations. So imperative is the need to reduce coal consumption to a minimum, that a rationing scheme for all industrial undertakings will be introduced shortly.

VERTICAL LOG BAND SAW.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.



The vertical log band saw illustrated on this page has been specially designed for edging and re-sawing heavy flitches and slabs after the logs have first been broken down on a horizontal log band saw, or other machine. It will cut pieces up to 18 in. wide off slabs or flitches of any width. The machine is also capable of breaking down logs up to 30 in. in diameter, and of any length.

It fulfils all the functions of a rack circular saw bench, while effecting a great economy as compared with that machine, especially when dealing with the more valuable classes of timber. Owing to the varied purposes to which this machine can be applied, it will be found a most useful addition to saw mills where logs in any quantity have to be converted and is specially recommended by the makers, Messrs. A. Ransome and Co., Limited, Newark-on-Trent, for railway carriage and wagon work.

The saw pulley spindles run in special roller journal bearings enclosed in dustproof housings. The saw pulleys are 54 in. diameter by 5 in. wide and are mounted on shafts of large diameter made of a special quality of forged steel and accurately balanced. The top pulley has a cast-iron rim and hub with turned steel spokes cast in. The bottom saw pulley is very heavy, to prevent the saw over-running, with a solid central web. The pulleys are mounted between heavy vertical columns, and the top pulley is canted by turning a hand-wheel at the front of the machine. The tension to the saw blade is very sensitive, working on knife edges, and can be varied to suit saws of different widths and gauges by shifting a weight along a horizontal lever. Adjustable saw guides are fitted immediately above and below the wood, the upper one being provided with a quick vertical counterbalance adjustment to suit different depths of cut. A brush and scraper are provided on each saw pulley, and a pad is furnished for cleaning the inside face of the saw. A special paraffin box is also included for use when cutting resinous woods.

The feed ranges from 4 ft. to 80 ft. a minute, but, if desired, the rate of feed can be increased. It is driven by Ransome's patent friction gear controlled by a hand lever, by which the operator can instantly vary the rate of advance of the log, changing from the slowest to the fastest, or any intermediate speed; by this arrangement a maximum production is obtained. The feed may also be instantaneously started or stopped independently of the saw.

The return motion of the carriage, which is 200 ft. a minute, and is also worked by friction gear, is operated by another lever, which enables the sawyer to start instantaneously, reverse, or stop.

The travelling tables are for material 20 ft. long, but can be supplied of longer or shorter lengths, if desired. The front table is 24 in. and the back table 15 in. wide. Each table is provided with a strong cast-iron rack gearing with the steel pinions which actuate the feed. The tables are fitted on the underside with longitudinal stiffening bars which also form a guide maintaining the table in a perfectly straight line. The table runs on a series of cast-iron rollers with steel spindles, rotating in cast-iron carriages bolted to the floor of the mill. The rollers on which the table travels are flanged so as to form a guide for the bars on the underside of the table. A strong cast-iron fence is provided, with a traverse of 18 in. by means of a rack and pinion motion actuated by a hand-wheel.

While the machine is provided with every device for ensuring the most perfect work and facility of manipulation, the design throughout is such that there are no parts liable to breakage or undue wear, so that with ordinary care it should last in constant work for several years without repairs. The table annexed gives detailed particulars.

Dimension of Saw Pulleys.	Length of Material.*	Weight for Pieces 20 Ft. Long.	Brake Horse-Power.	Size of Fast and Loose Pulleys (for Saw).	Speed (for Saw).	Size of Driving Pulley (for Feed).	Speed (for Feed).
54 in. × 5 in.	20 ft.	7 tons	40	24 in. × 7½ in.	550 revs.	12 in. × 4 in.	800 revs.

* This machine can be made to deal with pieces of greater length than specified above.

Ductility of Metals and the Periodic Law.—When the atomic volumes (the quotient: atomic weight/density) of the elements are plotted against the atomic weights, the curve shows a series of sharp peaks taken up by the alkali metals, lithium, sodium, potassium, rubidium, caesium, the last-mentioned element having the highest atomic volume. Lothar Meyer, one of the originators of the periodic system, has pointed out that on this curve of his most ductile metals lie near the maxima or the minima (the peaks and troughs) of this curve. According to G. Tammann (Göttinger Gesellschaft für Wissenschaft, 1917), the occurrence of ductility depends on the formation, by the application of little force, of a great number of slip-planes in the direction of the main extension; he understands ductility in the sense that a body is ductile when it can be drawn into wire. Ductile elements, he finds, occur in various crystalline forms. The ductility is not dependent on any definite form of space lattice, but seems to be connected with the occurrence of only one kind of atoms, and these are not bound together by active valencies in the lattice of their crystals. When the valencies become active, as in alloys, the tendency to the formation of slip-bands is checked, and the ductility is diminished.

GENERATORS AND MOTORS FOR THE PROPELLING PLANT OF S.S. "WULSTY CASTLE."

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

(*For Description see Page* 140.)

FIG. 50.

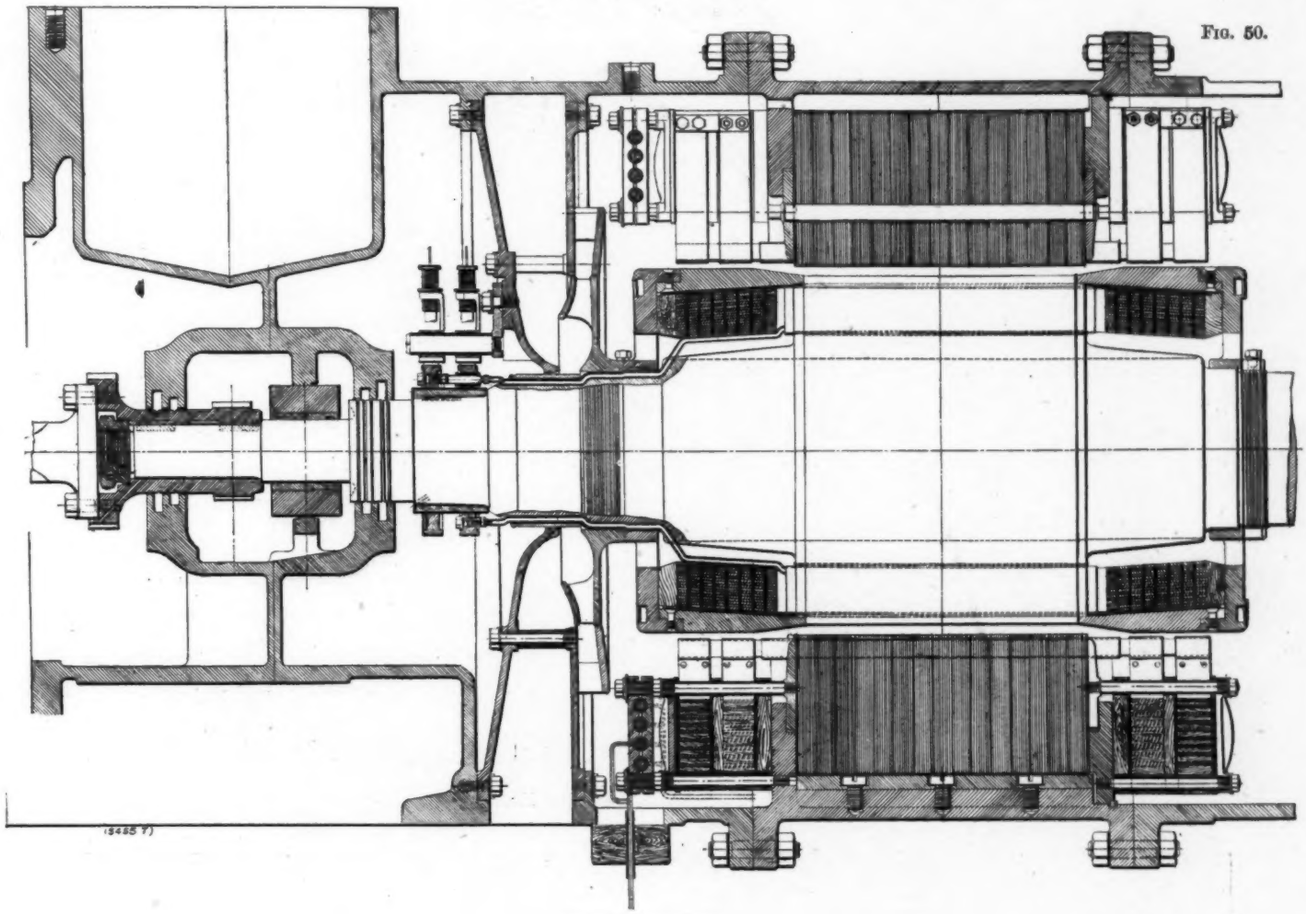
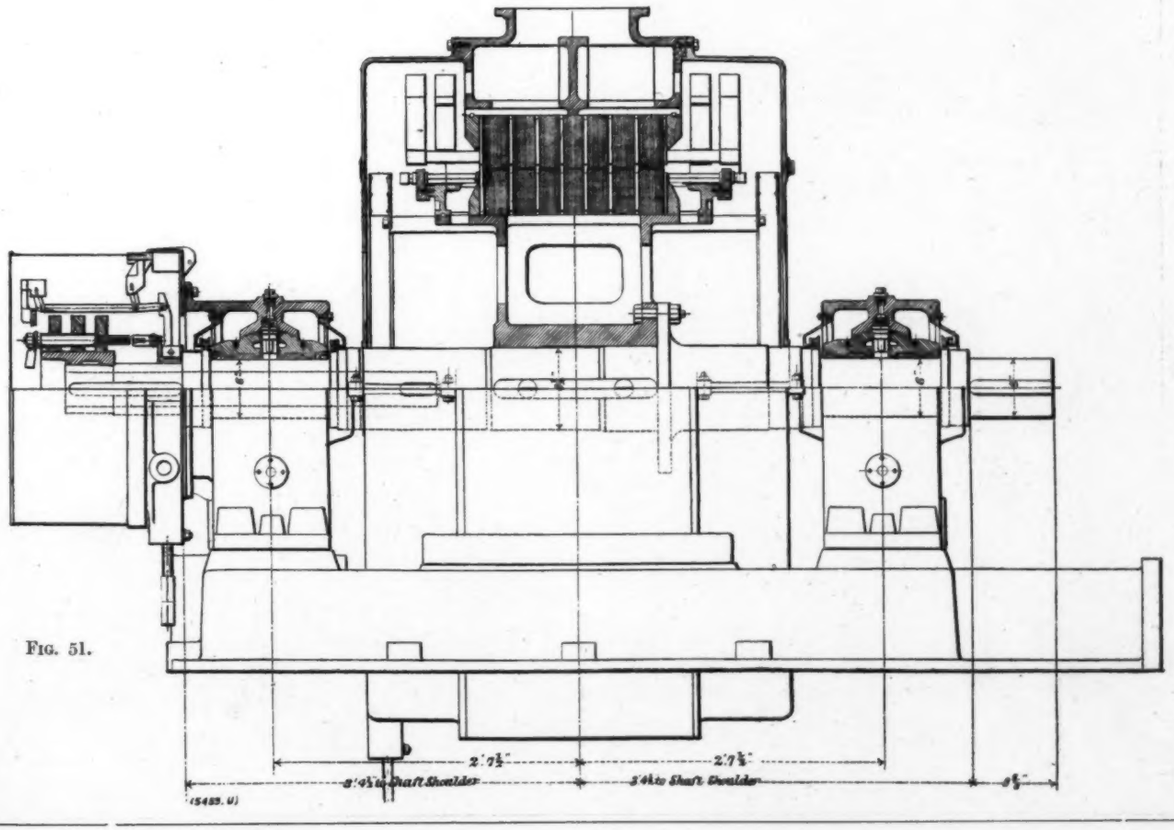


FIG. 51.



(*To face page* 140.)

INDUCTION MOTORS FOR THE PROPELLING MACHINERY OF THE S.S. "WULSTY CASTLE."

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

(*For Description, see Page* 140.)

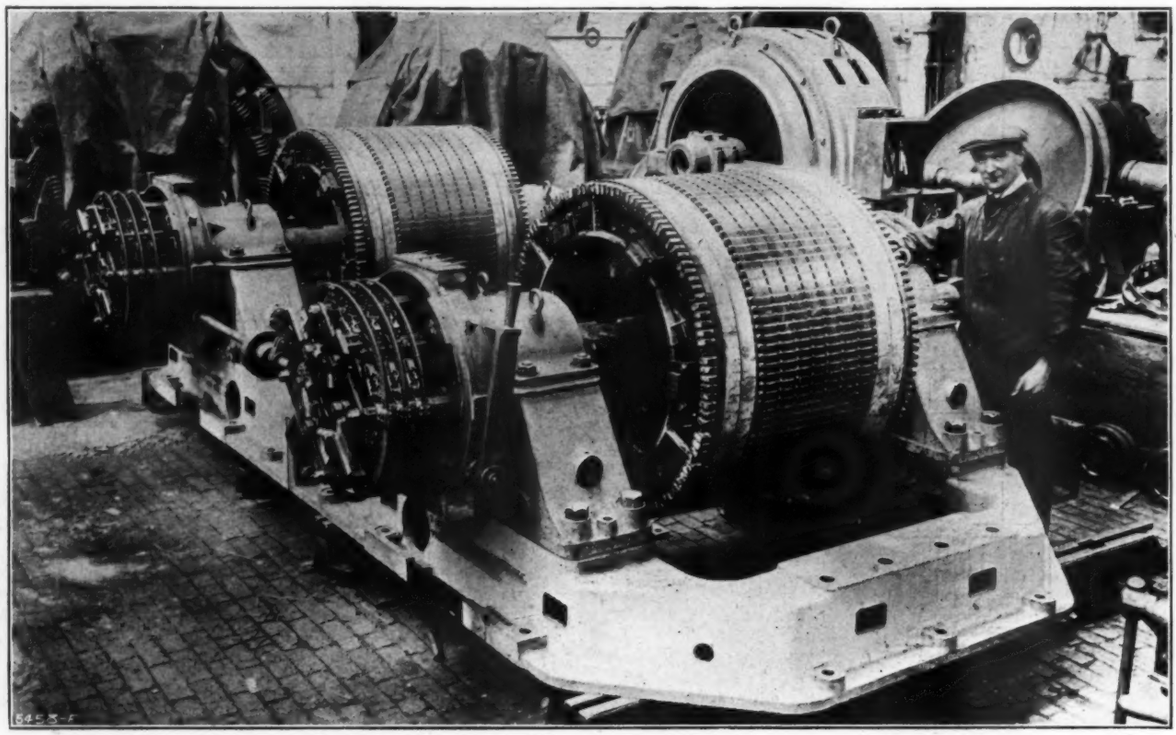


Fig. 52. Rotors for Induction Motors.

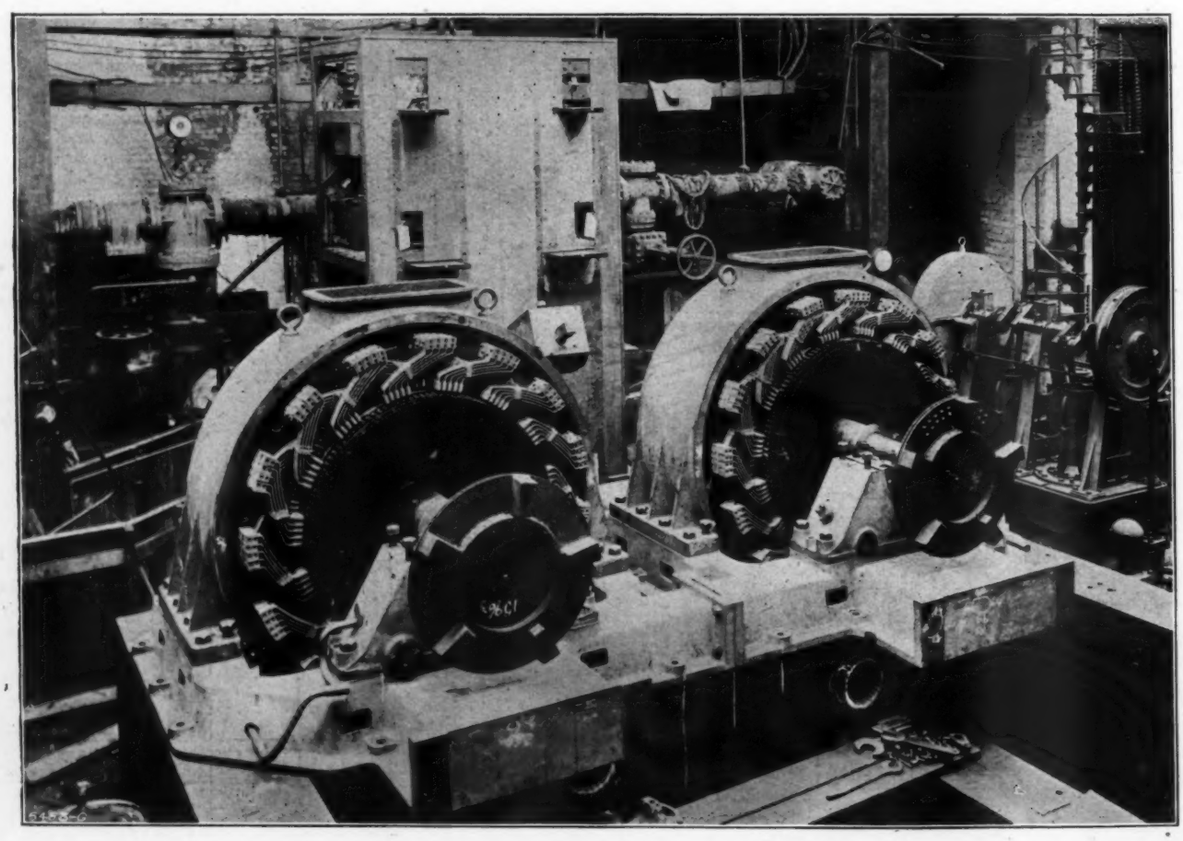


Fig. 53. Induction Motors in Course of Erection.

REDUCTION GEARING FOR THE S.S. "WULSTY CASTLE."

CONSTRUCTED BY THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON.

(*For Description, see Page* 140.)

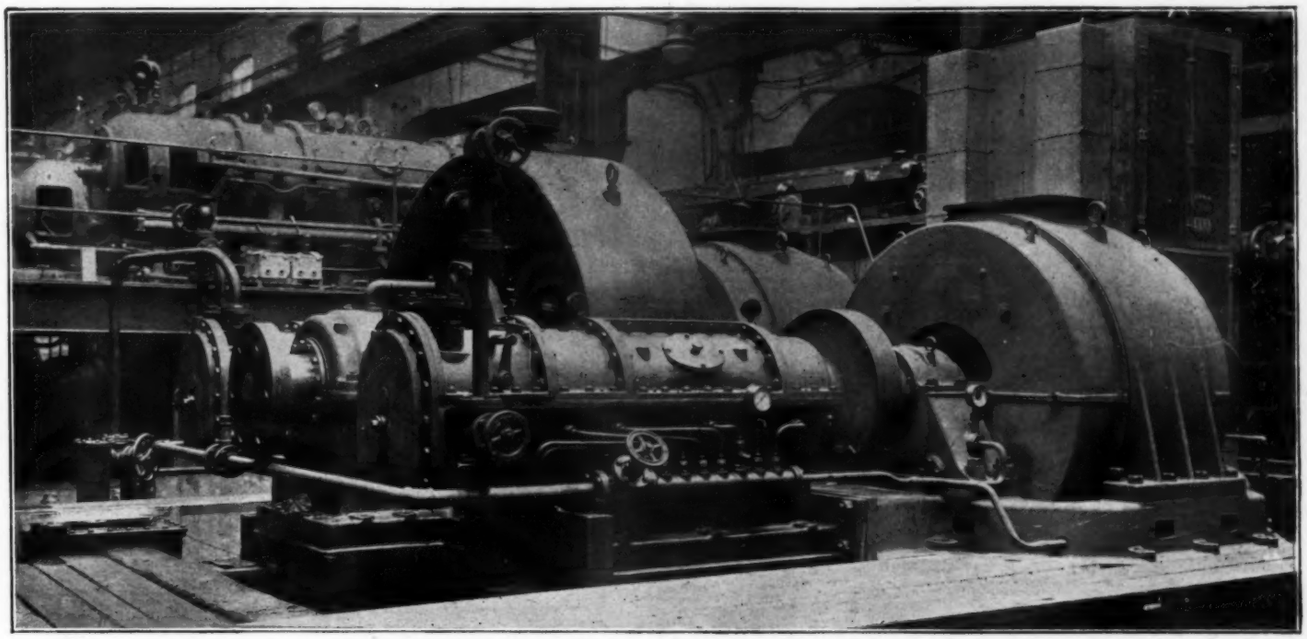


Fig. 55. Motors Control Gear and Reduction Gear Erected in Shops.

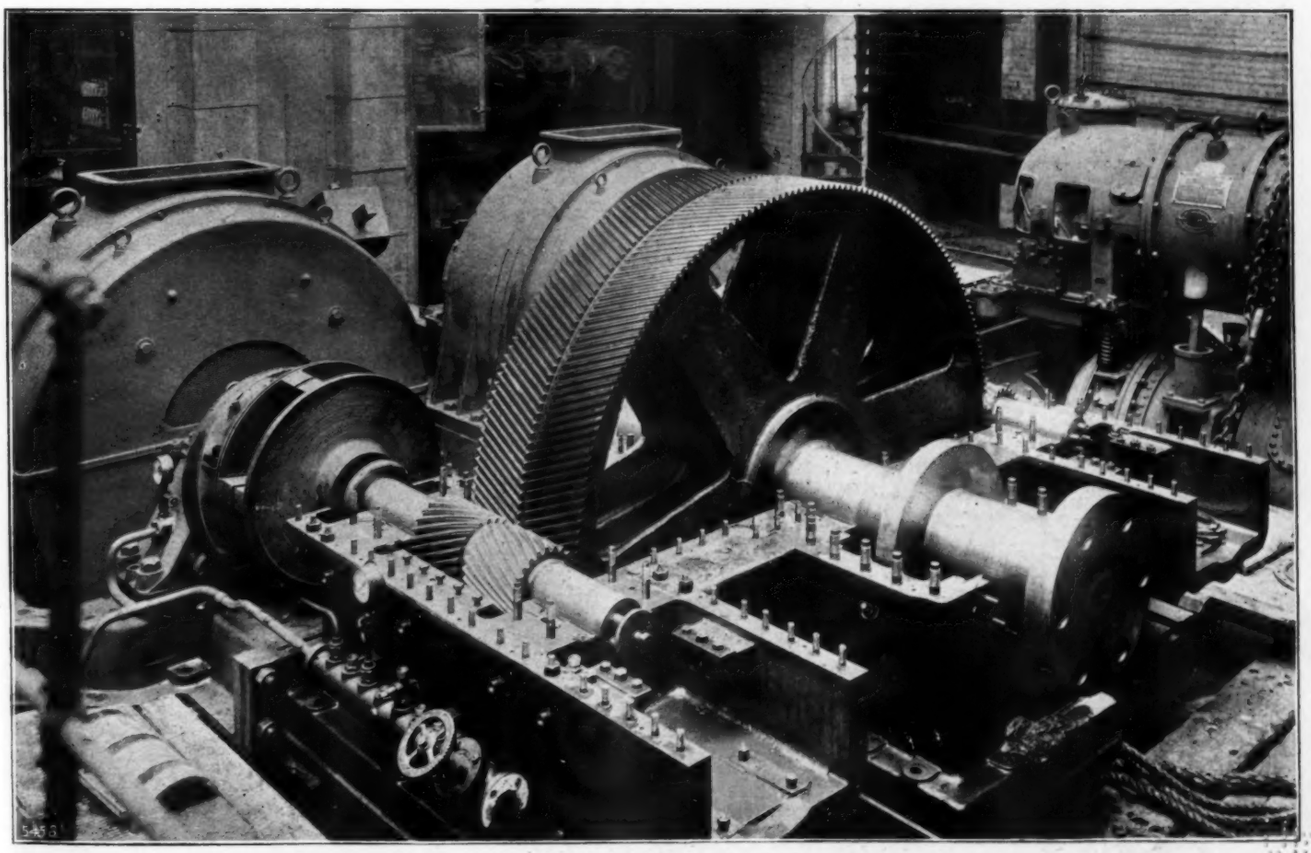


Fig. 56. General View of Double Helical Reduction Gearing.

DETAILS OF THE LJUNGSTRÖM TURBO-ELECTRIC PLANT FOR S.S. "WULSTY CASTLE."

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

(*For Description, see Page* 140.)

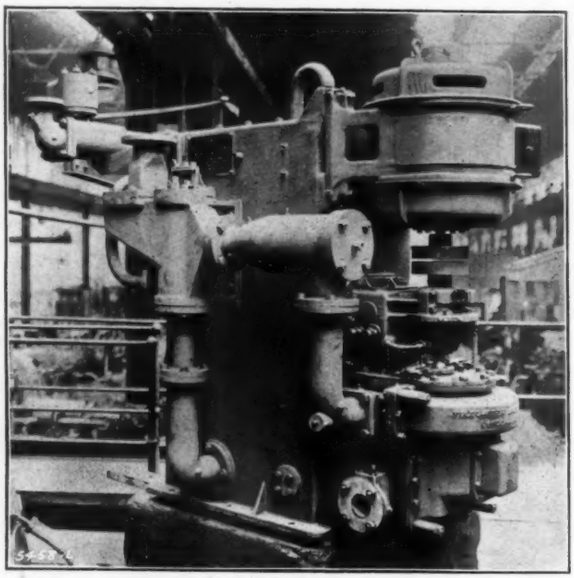


FIG. 57. PUMPING PLANT FOR CONDENSER.

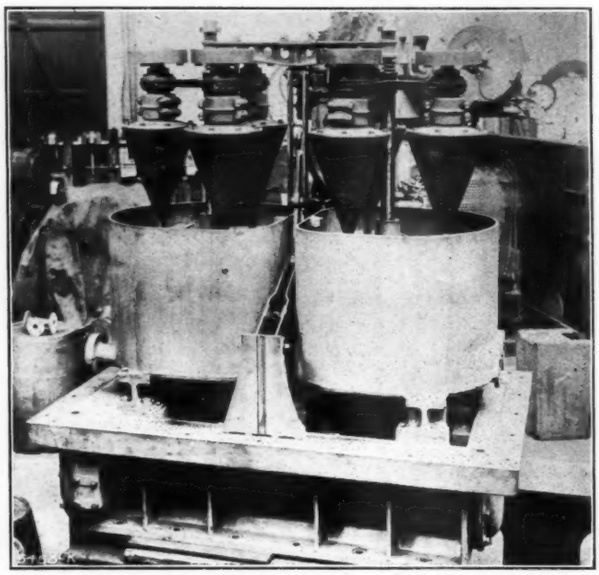


FIG. 58. VARIABLE RESISTANCE FOR CONTROLLER.

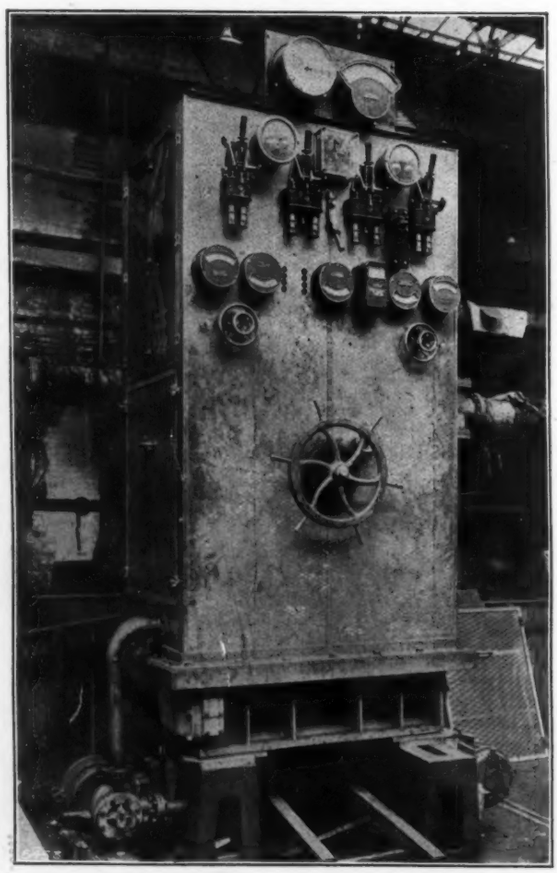


FIG. 59. FRONT VIEW OF CONTROLLER.

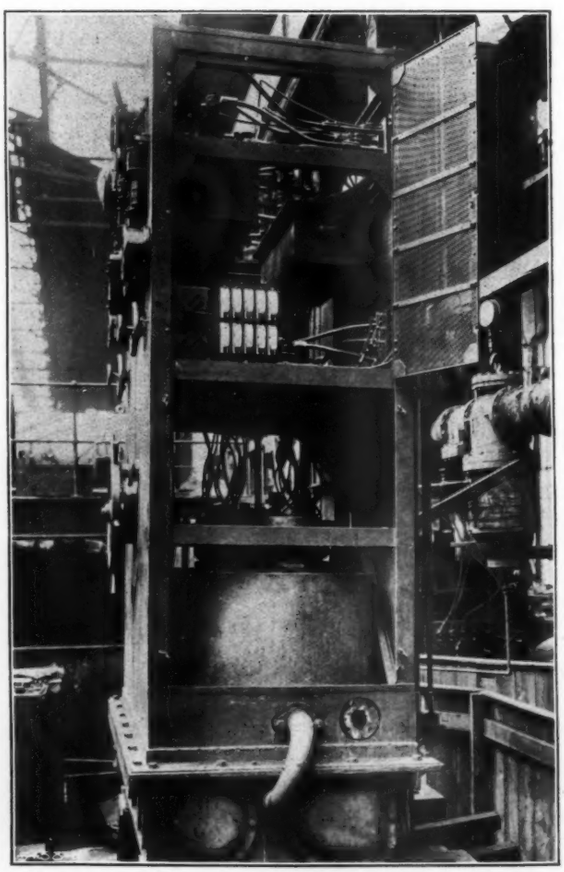


FIG. 60. SIDE VIEW OF CONTROLLER.

(*To face page* 141.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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With Four One-Page Plates of the LJUNGSTRÖM TURBO-ELECTRIC SYSTEM OF SHIP PROPULSION.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 145.

ENGINEERING.

FRIDAY, AUGUST 9, 1918.

STRUCTURAL ENGINEERING.

IT is not many years since that an eminent American bridge engineer denounced the plate girder as the most unscientific of all bridge structures, whilst another applied the same opprobious epithet to the Forth Bridge on its completion. In both cases the underlying assumption made was that to estimate the safety of a structure it was necessary to be in a position to evaluate with accuracy the maximum stress carried at any point. In a very interesting and suggestive paper recently published in the *Revue Generale des Sciences*, M. Charles Rabut, formerly ingénieur de la construction au Chemin de fer de l'Ouest, seems to accept this contention as correct, but maintains most strenuously that the usual methods adopted for determining such stresses are invariably grossly in error. The assumptions necessary to make feasible the computation of stresses in complicated structures are, he observes, far from being satisfied in practice. On this point M. Rabut is able to speak with indisputable authority. Over a period of many years he made innumerable measurements of the actual stresses attained in different bridges belonging to the Western of France Railway, and compared his observations with the values of the stresses as computed on the ordinary assumptions. He found that in web members the measured stress had often three times the computed value, and it was seldom less than twice as great. On the other hand, he found the stresses on the flanges and chords of main trusses were often markedly less than the computed values, and it was thus possible to maintain in service a number of bridges which the average computer would have condemned as greatly over-strained. In fact, Hemibique's principle that every part of a bridge forms in actual fact part of the main truss, is as applicable to ordinary steel structures as to the ferro-concrete monoliths for which it was devised. Thus the floor of a bridge commonly adds considerably to the flange strength of the trusses. For example, when it was proposed to lengthen the bridge which carries the Rue Legendre over the tracks of the Western railway in Paris, a measurement of the stresses on the bridge showed that this effect of the roadway had most materially reduced the flange stresses below their calculated values. M. Rabut was able accordingly to lengthen the original girders by no less than 8 m., increasing the span from 40 to 48 metres, without having either to reconstruct them or to strengthen them.

American bridge engineers have also recognised this effect of the floor, but in place of utilising it in order to increase the factor of safety of the structure they, in several cases in the past, adopted the extraordinary expedient of cutting the floor up into a series of independent lengths in order to eliminate any reinforcing effect it might have on the effective strength of the trusses. In this way a closer relationship between the actual and the computed stresses was retained (a consummation much desired by the older school of American bridge designers), but at a considerable, if not easily evaluated, reduction in the real factor of safety. In some more recent large bridges such as that over the Ohio River at Sciotoville, however, the more scientific plan of making the floor continuous has been followed.

As already observed, M. Rabut appears to accept the view that the maximum stress on a structure is the measure of its effective strength. He merely differs from German engineers and the older school of American bridge engineers in maintaining that these stresses should be measured rather than computed. Undoubtedly this policy is an improvement on its rival, but it is at the same time quite certain that the maximum stress, even if experimentally determined, is by no means necessarily a measure of the safety of a structure. It is quite easy to devise a structure in which the maximum stress is double that in an alternative design, and yet, although the materials used are of the same kind and quality, the factor of safety may be two or three times as great as that of the structure with the lower stress.

M. Rabut, in view of his observations on the actual stresses in the web members of a truss, advocates the complete abandonment of the ordinary type of triangulated truss in favour of the Vierendeel system, in which actual experiment has shown a much closer accord between the calculated and the actual stresses than is found to exist in the usual types of triangulated trusses. Any expression of opinion by M. Rabut is entitled to very serious consideration, as not only does he stand pre-eminent amongst those who have made a study of the actual stresses in steel structures, but he has also been the responsible designer of a number of important bridges, some of which have been at once remarkably bold and perfectly successful. Nevertheless, his verdict in favour of the Vierendeel type seems open to criticism. The fact that calculation and observation agree seems no means conclusive as to the superiority of the Vierendeel system. In fact, as James Thomson pointed out seventy years ago,* it is in many cases not the maximum stress on a structure, but the range of stress which constitutes the measure of its safety. This range of stress is proportional to the live load, and is generally independent of such internal stresses as may arise from the fact that joints are rigid and not flexible as assumed for the purposes of calculation. It is perhaps questionable whether any structure has ever failed because a compression member (in place of being free at the ends, as assumed for the purpose of calculation) was actually firmly fixed at its ends to adjoining members. In fact, in most cases this fixation in place of reducing the ultimate resistance of a strut (owing to the bending moments developed) will actually increase it. It is thus, to say the least, doubtful, if in actual practice a Vierandeel truss will show as high a service strength as a well-designed triangulated truss of equal weight. A secondary stress, it should be observed, is one which is capable of relieving itself by a local permanent yield of the material. Such a yield will not generally compromise in any way the safety of the structure as a whole, at any rate, so long as the stress is not alternating in character. Even in this latter case, moreover, though a local crack may develop and give trouble, it will seldom involve any immediate danger to the stability of the structure as a whole.

M. Rabut criticises as irrational the practice of the Government departments of all countries in specifying the safe loading for structures, not on the basis of the actual stresses, but on the stresses as calculated in the conventional way on premises which are in many cases demonstrably wrong. Possibly, however, this practice is more defensible than would appear from this presentation of the facts. Very few experiments, for example, have been made on the actual stresses in ship structures, yet ships of new types and sizes have been satisfactorily proportioned by just such a process as M. Rabut condemns. A ship is taken which has proved satis-

* Cambridge and Dublin Mathematical Journal, November, 1848.

factory in service. It is assumed to rest on the crest of a wave of a length equal to that of the ship and the stresses on the structure calculated on this basis. The new ship is then proportioned to have no higher stresses when exposed to a precisely similar arbitrary loading. No doubt as time goes on some accurate data as to actual stresses in service at sea will be accumulated, but even such knowledge obtained by "ausculting" ships as M. Rabut has ausculted bridges will hardly make it possible to avoid the use of an arbitrary conventional load in estimating the scantlings for a new type. The case of a motor-car axle is still more difficult. Should official rules ever be promulgated for these, they must necessarily be arbitrary in character as no one knows, and it seems hardly practicable to determine, what the actual stresses are in such axles when a car is driven at high speed over a rough road. All that it is practicable to do is to calculate on certain arbitrary and necessarily inaccurate assumptions the stresses on an axle which has proved adequate in service, and then to proportion other axles to have no greater stress, as calculated on the same conventional and inaccurate bases. Hence the official rules and regulations for bridges may be quite defensible if considered simply as a means for the comparison of a proposed new structure with others which have given good service in the past. Of course, the objection does lie that the new structures may depart widely in details from those with which the comparison is thus made, and to this extent the procedure is certainly defective.

In this connection M. Rabut states that a very important step forward has been made by the French Ministry of Public Works. Whilst the existing regulations as to calculated stresses are not abrogated, the department announced in 1916 that these rules would not be enforced in cases where bridge engineers were able to justify their designs by direct experiment. This is a very bold step for a beaurocracy to take, and it is to be hoped that the usual desire in all countries of Government officials to evade responsibility will not soon render the concession a dead letter. This would certainly be its fate in this country, if we may judge from the record of the Board of Trade in regard to the provision of life-saving appliances at sea. When certain regulations were first published it was announced that where the shipowner made special provisions of another kind, certain of the specified requirements might be relaxed. It was given in evidence before the Titanic inquiry commission that the department had never once allowed a shipbuilder to take advantage of this clause, however much he might have added to the safety of crew and passengers by exceeding the Board's requirements in other directions.

M. Rabut anticipates a vast extension in the employment of reinforced concrete. In fact, he maintains that for bridges of spans less than that for which the suspension bridge becomes advisable the concrete bridge will supersede steel, and even in the case of suspension bridges ferro-concrete may, he suggests, be used for the roadway and stiffening girders. Already one concrete bridge has been built in France, with a radius for the arch of 130 m. (426 ft.), the span being 96 m. (315 ft.). In this case the effect of the sprandrels in adding to the strength of the arch was taken into account, the results of the troublesome and tedious calculations being checked by studying a glass model of the structure by means of polarised light, a method of stress determination first suggested by Sir David Brewster. This method, it is interesting to note, is now being somewhat extensively employed in this country for evaluating the stresses in certain complicated structures.

One objection to the rigid arch is, of course, the troublesome character of the calculations if made in the ordinary way. One method of diminishing this trouble is to fix definitely the value and position of the thrust at the crown by means of jacks. In this way the thrust can be regulated so as to adjust the stresses exactly as desired. This plan has, M. Rabut states, been adopted in France by Freyssinet, and it has also, we may add, been used in Canada.

In this connection we may perhaps call attention to an important paper by Mr. J. A. L. Waddell, published in the March issue of the Journal of the American Society of Civil Engineers. In this paper Mr. Waddell gives the results of an exhaustive and most laborious inquiry into the economics of steel arch bridges, comparing the relative weights of arches with three hinges, with two hinges and with no hinges, for spans ranging from 100 ft. up to 2,500 ft. On the assumptions made he finds that the three-hinged arch is a little heavier than the two-hinged, but is nearly always lighter than the hingeless type. No doubt this result is correct on the assumptions made, but it is quite probable that in actual fact the superiority really lies with the rigid structure since, as we have already observed, stress is not always a certain criterion of strength. The less statically determinate the structure the less conclusive is the stress criterion as a measure of its safety.

OIL FUEL FROM BRITISH SOURCES.

The report* of the Committee appointed by the Minister of Munitions to consider the possibility of substantially augmenting the production of oil fuel from British sources is distinctly disappointing. A previous report submitted by the Petroleum Research Department had raised our hopes as to the possibility of obtaining, by the distillation of cannel coal, a material addition to our imported supplies of this now indispensable commodity. In fact, the last-named Committee had proposed to establish forthwith over a hundred batteries of retorts specially designed for extracting their oil content from cannel coal and kindred materials. Each battery of retorts was to be capable of dealing with 100 tons of the raw material per diem.

The Ministry of Munitions agreed, and the present report ratifies the wisdom of the decision, to erect at Nottingham a battery of these retorts capable of handling 50 tons of cannel per day; but before venturing on the larger scheme appointed another Committee to re-investigate the question, taking into account other factors than those connected with the purely technical aspect of the question. Technical questions remained, however, of prime importance, and engineers will be relieved to learn that although not officially constituted a member of their body, the Committee had throughout their inquiry the assistance of Sir George Beilby, whose competence in the matter under review is incontestable. Greater weight will accordingly be accorded to the findings of the report than would otherwise be readily conceded to the views of a body of which so large a proportion of the members were either mere politicians or departmental officials.

The recommendations of the Petroleum Research Committee are dissented from on several grounds. In the first place, it is stated that instead of a daily supply of some 12,700 tons of cannel coal being available, the present output does not exceed 2,000 tons a day, practically the whole of which is sold either mixed with other classes of coal, or is sent to gas works for enrichment purposes. With respect to that portion which is now sold mixed with other coal, the Committee are advised that the labour which would be required to sort it out is not now available. Indeed, any increased output of cannel coal would, as matters stand, necessarily involve a reduction in the output of ordinary coal, and this reduction of tonnage would be greater than the increase in the output of cannel, since cannel coal is not only harder than ordinary coal, but occurs generally in thinner seams, so that the output per operative is materially reduced. The Committee agree that considerable supplies of cannel or kindred materials are incorporated in the spoil banks at many pit heads, but they are convinced that under present conditions of labour this source of supply is unworkable. A further objection taken to the ambitious scheme of the Petroleum Research Department is the cost of the plant. The Nottingham battery designed to deal with only 50 tons per day will cost 25,000*l.*, so that the expenditure on the complete scheme would run into millions, and even so the total additional supply of oil fuel would meet but a small fraction of our annual requirements. Of course, even a small addition to the supplies of a commodity may effect more than a proportionate reduction in the average market price, but under present conditions the circumstance that the vast bulk of our requirements must, in any case, be met by imports does add additional weight to other arguments against proceeding further with the scheme of the Petroleum Research Committee. The difficulty of securing the necessary labour would in itself be practically decisive. One argument advanced by the Committee does, however, seem open to objection. They submit that although the Chiswick type of retort has worked most satisfactorily under expert supervision, it may give trouble if the attempt be made to operate it without such assistance. This contention naturally leads to the query as to why such an attempt should be made? The circumstance that in the past many British industrial undertakings have prided themselves on "not having a scientific man in the place" seems insufficient warrant for continuing the disastrous tradition, and if the Chiswick retort can be operated only under scientific direction it would surely be better to abandon a pernicious precedent than a promising industrial process.

An alternative to the scheme of the Petroleum Committee is to increase the production of oil at town gas works, since it has been proved that the ordinary vertical retort can be operated so as to efficiently extract the oil from cannel. The modifications necessary would require relatively little expenditure of time or labour. Nevertheless the Committee express themselves as adverse even to this scheme for increasing our native supplies of oil fuel, in view of the difficulties involved in an increased output and transport of cannel coal. In short, they hold that the attempt to increase our supplies of oil by carbonising home produced materials would involve serious interference with other essential industries.

In other circumstances, with transport less congested, and ample supplies of labour available, some of the drawbacks advanced by the Committee will no longer apply. In fact, they report that it should be possible to obtain from every 20,000,000 tons of coal consumed in the country, 1,000,000 to 1,250,000 tons of fuel oil. In 1915 it appears that the home consumption of fuel was not less than 193,000,000 tons, which, on the Committee's figures, should, under appropriate treatment, be capable of yielding about 10,000,000 tons of fuel oil. Other bye-products would also be available, but, of course, the capital expenditure involved would be very large, and in the present temper of public opinion it seems certain that Parliament would use its best endeavours to compromise the success of any undertaking of this kind by restrictions designed to prevent enterprise and ability from receiving an adequate reward. Economic materialism has been too long an established creed in this country to be readily uprooted, and promises to seriously handicap the nation in the industrial developments which will be essential to the liquidation of our enormous war debt.

* Production of Oil Fuel from Home Sources. H.M. Stationery Office. [Cd. 9128.] Price 1*d.*

THE ANNEALING OF GLASS.

Glass has to be annealed to remove any strains set up in it by improper mechanical or thermal treatment, and the presence and development of strains is revealed by passing a beam of polarised light through the glass. Although this optical method of examination has long been applied by physicists and manufacturers of optical glass, it is hardly known to the average glass manufacturer. The Department of Glass Technology of the University of Sheffield has therefore investigated the annealing of glass and the relationship between the composition of a glass and the suitable conditions for its annealing with the special object of facilitating the optical examination and of devising simpler mechanical methods of testing. "Notes on the Annealing of Glass," giving an account of these investigations, were communicated to a recent meeting of the Society of Glass Technology, by Messrs. Solomon English, M.Sc., and W. E. S. Turner, D.Sc.; the latter is in charge of the Department of Glass Technology at Sheffield. Though these notes were only offered as introductory, the details given are of considerable interest.

In a polarisation apparatus the beam of light,

polarised by passing through the first Nicol prism, is stopped by the second Nicol, when the two are crossed. On introducing a cylinder of glass, strained with fair regularity, between the two Nicols, some light will pass and a system of coloured rings will be seen, the number of rings increasing with the intensity of the strain. The strain can be removed again by proper annealing of the glass, and the glass manufacturer is mainly interested in three things: the "upper" annealing temperature at which the strain can rapidly be removed without risk of deforming the glass; the "lower" temperature at which the strain can be removed at a slow rate; and the quickest rate of cooling which may safely be used for cooling between the upper and lower temperatures without setting up new strains. For their optical examination, English and Turner use cylinders, 3 cm. in length, with plane polished ends which are placed in a tubular electric furnace. Such a specimen will, if severely strained, *e.g.*, show seven rings and the central black cross. As the temperature rises, the rings broaden and seem to chase one another out of the field of view; the number of rings thus diminishes, they become indistinct and vanish, leaving only the black cross, which finally occupies the whole field; that is to say, the field is uniformly dark when all the strain has been removed. In the experiments the times were determined at different temperatures which were wanted both (*a*) for clearing the field of rings and (*b*) for making the field quite dark, and it was observed that a temperature difference of a few degrees in a lehr or other annealing oven made a large difference in the time required. Thus the results were:

Tempera-ture.	Time Required. (*a*)	(*b*)
500 deg.	20·5 hrs.	?
550 ,,	50 min.	Not black after 9·5 hours.
600 ,,	20 ,,	4·5 hours.
625 ,,	—	18 minutes.
630 ,,	—	10 ,,

The glass of these experiments was of a fairly high "upper" temperature. In a lead glass, the upper temperature of which was only 450 deg. C., the (*a*) were 35 minutes, 20 minutes, —, and the (*b*) more than 6·5 hours, 130 minutes, 2 minutes at the temperatures of 400 deg., 425 deg., 450 deg. C.

Rapid annealing requires softening of the glass, and it was therefore investigated whether the rate of bending of heated sample rods and the rate of annealing would run parallel with one another. For this purpose a rod of the glass mounted axially in a horizontal tubular furnace, was fixed at the one projecting end, while the other free end played over a vertical scale; the sagging of the free end was measured. The general shapes of these curves proved the assumption just stated, and that glass anneals rapidly when the softening begins. Messrs. Beatson, Clarke and Co., of Rotherham, continued these tests. A test rod, 1 yard long, ¼ in. in diameter, was drawn out from the metal in question, and supported at its centre on a brick, which was placed on the pan carrying bottles down the lehr. Arriving at the cool end, the ends of the rod were each found to have sunk by ½ in.; in that case the bottles were found to be strained on examination. When the glass remained in the hot zone for about 15 minutes and was satisfactory, the ends of the rod had sunk by about 3 in.; with prolonged heating at higher temperature the bending became excessive.

As regards the rate of cooling, English and Turner find that the cooling rate should neither be uniform throughout the period, nor first be accelerated and then slowed down again, or *vice versa*, but that the glass may, first, *i.e.*, just below the annealing temperature, be cooled rapidly; as the glass stiffens the rate of cooling should be very slow, until the glass has become rigid, when the rate may again be accelerated. Thus the rate of cooling should be variable. Three stages would probably prove sufficient. In the first stage, glass of an upper annealing temperature of 585 deg. or 590 deg. C. may be cooled at the rate of 25 deg. per hour down to 500 deg. C.; during the next stage 500 deg. to 400 deg. C., even a slow rate of 9 deg. per hour gave rise to some strains; in the cooling-off stage the rate could once more be raised. Each stage would correspond to a different section of the lehr, and the question is, whether the annealing oven can economically be so constructed as to admit of varying the rates of cooling. When only one variety of glass is made, the mechanical difficulties would not be great; but when glassware of different compositions and different thicknesses are to be annealed together, which is the common practice, the fastest rate of passage will have to be adopted, it is pointed out, even if this rate be that of the slowest glass to be annealed. How much the chemical composition influences these rates is shown by the data of the paper. A glass containing 30 per cent. of lead oxide had to be annealed at 450 deg. C.; it could be cooled down to 400 deg, at the rate of 120 deg. per hour, but between 400 deg. and 300 deg. the rate should not exceed 50 deg. per hour, whilst below 300 deg. the high rate of 300 deg. per hour was permissible. These figures concern a rod 7 mm. in thickness. For electric lamp globes this glass could be cooled at the rate of 12 deg. per hour down to 300 deg. C., and then be allowed to cool off in the open air. Wine glasses could be treated in similar ways. Lime-alkali glasses had to be cooled slowly, at 10 deg. per hour, from 550 deg. down to 320 deg., the further cooling being completed in 3 hours. Boric acid glasses (with 23 per cent. of B_2O_3) proved surprisingly difficult to anneal at 570 deg.; as borax acts as flux and diminishes the expansion coefficient of a glass, one might expect ready annealing; but the important factor is the rate at which the viscosity varies throughout the temperate range in which annealing can occur. Chemical glassware containing, *e.g.*, 64 per cent. of silica, 10 per cent. of alumina, 7 per cent. each of barium and calcium oxides, and 11·5 per cent. of soda and potash, proved the most troublesome; between 500 deg. and 400 deg. this glass has to be cooled so slowly that Messrs. English and Turner had so far failed to get an 8-mm. rod through this region wtihout some signs of strain.

ALKALI WORKS IN 1917.

As in 1916 the annual report—the fifty-fourth of the series—presented by the chief inspector under the Alkali Act, Mr. W. S. Curphey, to the Local Government Board and to the Secretary for Scotland, summarises, without reproducing, the reports of the inspectors of the 10 districts, into which England, Wales and Ireland are divided for this purpose. Scotland forms a special district. Two of the inspectors, Messrs. H. J. Bailey and H. Porter continued to give their full services to the Explosives Supply Department of the Ministry of Munitions, Captain A. C. Carter remained on military duty, and the vacancy caused in 1916 by the death of Mr. E. Jackson not having been filled, only five district inspectors remained to deal with the increased duty. These are Messrs. T. Lewis Bailey, A. C. Fryer, A. M. Fletcher, Littlefield and J. W. Young (Scotland), assisted by Mr. E. Linder, Mr. Curphey's assistant. The number of registered works increased from last year, 1916, by 21 to 1,414, and the number of processes under inspection increased by 201 to 2,326. These figures—like other statistics which we shall quote from the chief inspector's report—do not comprise Scotland, which adds 168 works and 317 processes to the numbers. The report from Scotland is kept apart from the others, but we shall not observe this distinction in our comments. The number of visits paid to works and of tests made diminished considerably, owing partly to the curtailed railway service and to the difficulties of procuring vehicles to works at a distance from railway stations. The general averages (as well as the district averages) of pollution of the atmosphere were less favourable still than last year. An exception occurred, however, in the acidity of the chimney gases from sulphuric-acid concentration plants; in these works the pressure on the plant was lessened, especially during the latter part of the year, so that good working conditions could more easily be maintained than in 1916. Otherwise war conditions continued to affect the standard of working. Skilled men were called up, and there were difficulties with the supply of materials and transport; but the situation was faced, and repairs and extensions of plants and the introduction of new processes were persisted in. Again no proceedings were entered into for the recovery of penalties incurred by the contravention of the Act, though some would probably have been taken under other than war conditions; back fees were accepted from five works which carried on registrable processes without registration. The position of the Alkali inspector is rather peculiar in cases of pollution of the atmosphere. In one instance some allotment gardens had undoubtedly been damaged by acid gases; but many works' chimneys of the neighbourhood discharged acid gases; only some of these came within the scope of the Act, and in their cases abnormal gas escapes could not be traced. In another instance, concerning some nitre-cake works, the possibility of temporary escapes during certain stages was admitted under present labour conditions; but no evidence of any abnormal occurrence was found.

Alkali and Copper (Wet Process) Works.—Though the general average escape of muriatic acid from the chimneys of alkali and copper (wet process) works, amounting to 0·089 grain per cubic foot of chimney gases, was well within the limit of 0·20 grain, the limit was exceeded in some cases (including those just mentioned). Owing to the extended use of nitre cake in the place of sulphuric acid for decomposing salt the relative production of hydrochloric acid per unit of salt cake was lessened still more. The one mechanical salt-cake furnace mentioned last year* worked satisfactorily throughout the year, and a new electrolytic alkali plant was approaching completion. Some trouble with the heating of alkali waste heap is reported from Scotland.

Cement Works.—The number of cement works (56 in 1915) decreased further to 45, and the industry suffered owing to various restrictions, in spite of the new demands for concrete as a substitute for wood and iron in shipbuilding and other industries. In connection with the various potash-recovery processes, the cement industry would alone come within the scope of the Act, and little practical progress is reported; the variability in the composition of the raw materials and the uncertainty of the future stand in the way, in addition to general difficulties. Some preliminary work has been done, however, chiefly with respect to clay. As a source of potash clay varies much in content in different districts and also with respect to the kiln charge and the addition of chloride and fluoride to the charge to aid volatilisation of the potash.† In the gases and dust from iron blast furnaces, 50,000 tons of potash are estimated to be lost annually in this country, according to Mr. Kenneth Chance; but iron smelting is outside the Alkali Act.

Smelting Works.—In other smelting works the average acidity of the chimney gases rose from 3·01 in 1916 to 3·37 grains per cubic foot (reckoned as SO_3), while the average of all chimney gases improved slightly, from 0·932 to 0·900. The number of works had increased by five to 76 (75 in 1915). In arsenic-recovery and tin-smelting works the continued use of limestone and of milk of lime in wash towers did good service. The recovery of tin and wolfram might be much improved, however; according to Dr. Fryer more than 35 per cent. of these metals are lost, whilst a reduction of the loss to 10 per cent. or 15 per cent. would secure the resuscitation of many properties now closed down. More sulphur gases from zinc sulphide ores are now utilised for the manufacture of sulphuric acid, but the new mechanical calcining furnaces are still disappointing. For some reason the Alkali inspector cannot interfere when the calcination gases are discharged into the atmosphere, and this old practice still continues. Further progress is being made, however, in arresting the dust and fumes from smelting works by mechanical and electrical methods, and in thus reducing waste. Electrolytic methods for extracting calcined zinc sulphide ores are also advancing; but as these processes do not fall under the Act, Mr. Curphey merely mentions the fact.

Sulphuric Acid Works. Lead Chambers.—The average escapes of SO_3 from sulphuric acid works of the lead-chamber type (Class I) increased further to 1·342 grains per cubic foot (the maximum being 3·2). Much attention is being paid to the

* See ENGINEERING, August 24, 1917, page 205.

† Compare ENGINEERING, July 19, 1918, page 68.

advantages of the chamber process and of contact processes and of intensive working in chambers. The old style of plant works with large rectangular lead chamber space and small absorbing and denitrating towers; the newer style associates, in various ways, small chamber space with powerful "nitre" recovery appliances, and the chambers themselves have the dimensions of towers, being either empty and externally water-cooled, or packed with material to provide contact surfaces between the circulating gases and the descending liquid. The chamber space now ranges from 25 cub. ft. down to 6 cub. ft. or 7 cub. ft., per pound of sulphur burned per 24 hours; in the tower chambers of the Mills-Packard type (external water-cooling) the chamber space is only 3·6 cub. ft. to 4·5 cub. ft., and in the columns of the Opl system (packed with material for the acid flow) the available space (apart from material) is reduced to 1·25 cub. ft. Combinations of rectangular chambers and column-chambers are also in use. The relative times available for the actual reactions were in one works estimated at 144 minutes in the old chambers and at 12·3 minutes in the new Opl columns of the plant. As the time for reaction is reduced, the sensitiveness of the devices increases, and there is hence more need of skilled supervision. This is in itself by no means a disadvantage, though some proprietors are still very prone to listen to any suggestion for reducing cost of production by lowering the expenditure on management. By analysing and testing the gases before entering and after leaving the Glover and the Gay-Lussac towers* considerable economies have been effected in a few works, notably in the Broxburn Oil Company, Scotland. In these works the tests made are entered upon a chart which is open to the inspection of the men, who are thus enabled to control their own work and take more interest in it to the general benefit. Though the general tendency is in favour of small chamber space, it does not necessarily follow that the advantage lies with the smallest space; too many factors come into play. The introduction of iron contact towers between the burners, and the Glover tower has not proceeded as rapidly as was anticipated. The adoption of catalytic methods for supplying the nitrogen oxides necessary for the chamber process (instead of decomposing sodium nitrate with sulphuric acid by the "potting" method) is a new feature for this country; the new method gives a continuous uniform supply of nitrogen oxides and saves sulphuric acid. One serious case of poisoning by nitrous gases and one fatal case occurred in Scotland. In the latter instance a thick-walled cast-iron vessel containing a mixture of sulphuric and nitric acids collapsed from some obscure cause, possibly because the acid had corroded the metal and the crystallising iron salts had strained it. A destructive accident by fire was aggravated by the fact that nitre was stored in an endangered position; nitre bags, Mr. Curphey points out in this connection, should carefully be washed after emptying as their accidental ignition has caused serious fires.

Sulphuric Acid Works (Class II, Contact Processes).—Plants for the highest strength acid (oleum) have further increased (137 works against 112 in 1915), and they are of three types: (1) The contact material is oxide of iron; oleum is produced and the residual gases are utilised for making chamber acid in towers; (2) both oxide of iron and subsequently platinum serve as contact materials; (3) platinum contact material is alone used. In a modification of (1) no oleum is made, but by mixing acid from the contact section and from the chamber section, a less strong acid is produced. Plants of type (1) still give trouble in adapting the weak, cold and dry gases from the contact section to the chamber reactions—last year it was hoped that the use of steam would overcome this trouble; type (3) works most satisfactorily. The acid vapour escapes from concentration plant were, as was stated, high in the first half of the year, but improved later. High escapes occurred from some Gaillard towers; the Kassler plants did highly satisfactory work; opinions about the cascade system, which is in extensive use, differ; the Davis concentrator (mentioned last year) continues in operation with improved efficiency. Electrical methods are used to remove the acid spray from the fumes, and a new high-speed scrubber has been introduced for the same purpose. In this Calder-Fox scrubber the removal is effected by frequent sudden changes in the direction of the flow of the gases and by providing baffle surfaces to promote friction between gas and solid; the treatment only takes a very short time, a small fraction of a second, but like the electric precipitators, the scrubber mainly deposits suspended particles without acting much on the SO_2 gas, unless the treatment be associated with condensation of water vapour by cooling; when the concentration of the sulphuric acid is forced, a good deal of SO_2 may be generated. This limitation of the Cottrell (electric) process, *i.e.*, that it does not arrest the finest particles and gases, was noticed in the early years of its various applications and remains a source of disappointment. Complaints about damage done to chimneys by the gases come chiefly from Scotland, where the Kessler system is extending—there were 19 works of Class I and also 19 of Class II in Scotland—and the cascade system was not working satisfactorily. That was not necessarily the fault of the system, however. Dr. Bailey mentions that the adoption of mechanical stoking gave excellent results in a cascade plant, where the previous temperature fluctuations had been detrimental to the basins. A case of fire of a coke-packed scrubber had also little to do with the system. In order to prevent undue condensation of water to the detriment of the acid strength, the leaden casing of a scrubber was enclosed in 2-in. boarding, which took fire; the case is not an isolated one; sawdust packings outside the lead casing have been fired by the internal heat, and the gases must not be allowed to reach the scrubber too hot. One man was killed while cleaning out a railway tank wagon used for acid transport; having repeatedly flushed the tank with water, he entered the tank to remove the sludge in a new galvanised-iron bucket; the arseniuretted hydrogen generated from arsenic in the sludge overpowered him. His entering the tank was quite contrary to definite instructions, but the accident is greatly to be regretted.

Chemical Manure.—The number of chemical manure works has been decreasing during the last eight years and the number of processes worked is now down to 138 (164 in 1909); but many of the closed works were small, whilst the remaining works have undergone extensions and alterations. Nitre cake is being used in the place of sulphuric acid for rendering the phosphate soluble (superphosphate) with varying success. The nitre cake can gradually be mixed with the ground phosphate, while itself being ground; the water poured on the mixture should be as hot as possible. The imports of mineral phosphates further diminished during the year. In Scotland the number of manure works (31) remained unchanged, and there was little use of nitre-cake so far; the amount of mineral phosphates and bones dissolved, 64,150 tons, was a little greater than in 1916.

Ammonium Sulphate and Muriatic Gas Liquor.—The 742 processes worked mark a further increase of 20 over 1916; Scotland has 109 of these works. More works have ceased to manufacture sulphate, producing directly concentrated ammonia liquor. The total recovery of ammonia (expressed in terms of sulphate) has again grown, the figures for the years 1915–16–17 being 426,267 tons, 433,703 tons, 458,617 tons; last year gas works contributed 188,478 tons to this total, iron works 13,621 tons, shale works 60,560 tons, coke-oven works 166,354 tons, and producer-gas and carbonising works (bone and coal) 29,604 tons. In Scotland, gas works produced 22,870 tons, iron works 12,765 tons, shale works 60,560 tons, bone, producer-gas and carbonising works 22,232; a total of 118,427 tons of sulphate, against 114,693 tons in 1916; out of this total, the equivalent of 17,689 tons was manufactured as concentrated ammonia. The sulphate production of the English gas works and of the coke-oven works increased, that of producer-gas works decreased, and the increase from the gas liquor (172,269 tons in 1916) was rather unexpected. Inferior coal was distilled in many gas works, more water-gas produced, more gas gained per ton of coal carbonised; steam was introduced into vertical retorts, the gas liquor was run to waste in some plants or turned into concentrated liquor with higher working losses frequently; all those adverse factors were, however, counteracted by the enhanced demand for gas.

Passing to technical detail, we read that the cyanides in ammoniacal liquor should be dealt with before the distillation. That is a problem which will have to be investigated, and the question also came into sad prominence with respect to one fatal accident reported from the distillation plant of a Scottish coke-oven works. Only one man out of a dozen men attending to a new plant was killed, and the cause of the death is obscure. Owing apparently to the pinkish colour of the blood of the victim, carbon monoxide poisoning was suspected; but there was no evidence of the presence of CO, nor reason for it, whilst cyanides were certainly present, and the bright-red colour of the blood, characteristic of CO poisoning, has also been observed with prussic acid poisoning.

Ammoniacal liquors of exceptional character having been submitted for analysis during the past year, a revision of the analytical methods, which were last reviewed in the annual report for 1909, has been entered upon by Mr. Linder, and the actual report deals particularly with the estimations of thiocyanate (sulphocyanide), of cyanides and of polysulphides in liquors. The second problem discussed at length is the "direct ammonium sulphate process." Though this process has only in quite recent years figured in the alkali inspectors' reports, it is by no means novel to the gas industry. Direct absorption of the ammonia in the crude gas, as it comes from the retorts, or only freed of the tar by bubbling it through acid, was in fact attempted in the early years of gas manufacture; it did not answer, and was later given up also in the Scottish shale industry, in which it had been adopted, and only revived again in the Mond gas process and for coal-gas by Brunck fifteen years ago. At present it looks almost as if the familiar scrubber which is charged with water for the absorption of the tar and of all the vapours that have passed through the condensers, would again prevail over the direct method, in which the cold or hot gases, deprived in some way of their tar, are bubbled through a solution of ammonium sulphate, in which an excess of sulphuric acid is maintained. So far the direct process has chiefly been used in small plants, which immediately distil the ammonium salts with lime to produce liquor (caustic ammonia), because the salts include chlorides, thiosulphates, &c., which must be decomposed. In one works the direct process has been abandoned. It has, however, been brought into more extended use in others, and further particulars are given of the continued experiments, conducted by the Alkali Inspector's Department in co-operation with the managers of three works.

Whatever the outcome of these researches, they will be of great service to the gas industry in general. For the main objection to the direct method, *i.e.*, that the ammonia recovery is poor, even when every effort is made to reduce working losses, rests partly on the assumption that 28 lb. or 30 lb. of ammonium sulphate are actually produced at the retort per ton of coal carbonised. But preliminary tests certainly indicated that this figure is not a universally applicable standard, and during the past year attention has mainly been directed to the systematic collection of data on the retort yields of ammonia under varying seasonal conditions. Those yields ought fully to be known by this time, it may be objected. But as a matter of fact, the accumulation in gas works of stocks which are not worked up as produced, and the impossibility of complete recovery at any stage, make statistical yield figures very unreliable unless based on very careful and continuous measurement and analyses, which are difficult to provide for. It may therefore be that the fault of the assumed poor ammonia recovery lies really in the carbonising house as much as in the bubbler and in the working losses of the direct

* In the cycle of the sulphuric acid chamber process the hot SO_2 gases from the calcining furnaces enter the Glover tower from below, meet there the nitrous sulphuric acid from the Gay-Lussac towers, pass through the lead chambers in series, and are denitrated in the Gay-Lussac tower; some acid is drawn off from the Glover tower, the bulk from the chambers.

method. Pyrometers (optical, Féry type) have been introduced for the determination of retort bench temperatures, which, one might think, ought to have been done long ago.

Further temperature measurements have also been taken in the purifiers, which are much affected by humidity and cold, as was pointed out last year; model purifiers have been devised which can be heated by steam pipes; the pipes are subject to rapid corrosion unfortunately. Neutralising boxes have been added to the bubblers, charged with ammonium sulphate and an excess of sulphuric acid, which are certainly not perfect as absorbers. One source of loss in the bubblers is the formation of a surface scum which may be largely tarry or largely arsenical; the scum should neither be thrown away, as it contains a good deal of ammonia, nor be returned to the liquor well, but should be specially treated with steam. The ammonia stills have been perfected on the Liebig-condenser principle, and evaporation losses of the ammonia produced and stored have been reduced. The success of many suggested improvements, *e.g.*, of working purifiers on the rotation system coupled with the downward flow of gases, will mainly depend upon the chemical engineer. The details of the experiments and of the observational data collected are of great interest.

As regards further sources of ammonia, the report points out that supplies should be ample in the future. A large proportion of the coal annually consumed is not at present treated so as to permit of ammonia recovery; the use of steam in vertical retorts promises higher ammonia yields, and synthetic ammonia processes are making rapid advances over here, as on the Continent and in America. The only figures given refer to Germany, where the Haber process was estimated to yield 30,000 tons of ammonia (calculated as sulphate) in 1913, and 500,000 tons in 1917.

Nitric Acid.—The number of works increased by one to 101 (88 in 1915); there are eight works in Scotland. Synthetic methods are used in several of these, in addition to the older methods, and with their advance the question of the nitre-cake utilisation becomes less important. The one fatal case mentioned of gassing by oxides of nitrogen unfortunately once more emphasises the invidious character of these gases. A bricklayer repairing the outside of a roof close to the exit of one of the recovery towers became affected; the case was not considered serious and not reported to the manager, but the man died within 50 hours of the gassing.

Chlorine and Muriatic Acid. Tin Plate.—Electrolytic methods for the production of chlorine (altogether 96 works in England, 6 in Scotland) and also of chlorates were expanding. An obscure case of fire occurred in the coke tower of a Deacon plant. The tin-plate industry (71 works) was adversely affected by the difficulties of supply of labour and material; nitre-cake is replacing sulphuric acid for pickling; the troubles with escape of gases from tin-plate flux works have not diminished.

Sulphide and Arsenic. Picric Acid.—The number of sulphide works, in which metals are precipitated by means of sulphuretted hydrogen increased by five to 101 (14 more in Scotland), and there were only two complaints against such works. When sulphurous gases escape together with arsenious fumes, Dr. Fryer finds that dry filters arrest the arsenious acid better than wash towers packed with limestone or fed with milk of lime. In the picric-acid works (now 21, against 13 in 1915; one works in Scotland) the noxious nitrous fumes were much reduced and methods improved generally, but there was much room left for improvement in the treatment of the waste gases in the recovery towers in which nitrous acid is converted into nitric acid.

Tar Works.—Lack of condensing power was also noted in some of the tar dehydrating plants, so that light oils were lost. Most of the 360 tar works (248 in 1915) are dehydrating plants of gas works, in which the fractional distillation, yielding tar for road maintenance, and light oils elsewhere to be treated for benzene and toluene, is not carried to completion. In the Scottish shale-oil works (50 tar processes) the complete fractional distillation has for nearly thirty years been conducted as a continuous process, whilst it is mostly intermittent in the tar works, apart from the Lennard continuous tar distillation (or fractional condensation) process, which is in use in a limited number of works. Fires due to the ignition of tar leaking from the stills into flues occurred in two works. The following figures of production are given: Tar distilled in gas works, 1,526,900 tons, in other works 126,999 tons; pitch produced in gas works 721,130 tons, in other works 74,829 tons; the production in gas works was a little higher, in other works a little lower than in 1916. The figures for Scotland were: Tar distilled in gas and coke-oven works 142,969 tons, in other works 119,189 tons; pitch produced in the same two classes of works 66,914 tons and 70,098 tons.

Zinc Works.—There has not been any change in the number of English zinc works (12) since 1915—there were 13 in 1913—but considerable extensions have been effected, and further extensions are under construction; electrolytic methods of zinc extraction are attracting increased attention, but the production need not be carried out in works registered under the Alkali Act. The calcining of zinc sulphide has already been referred to in our comments on smelting works. One of the two works of this class in Scotland experienced great difficulties in arresting the zinc fumes and in obtaining prolongs. A new style of prolongs adopted was blamed for a serious reduction in the output of metal, and the difficulties have not been overcome.

In his concluding remarks, Mr. Curphey acknowledges that the advantages of efficient scientific works' control and of co-operative efforts find more general recognition. He adds, however, that the latter efforts are not always associated with the desire to add special knowledge to the general store, and that there is too much tendency to look to the Government for guidance and support.

NOTES.

War Coins of the Central Powers.

The outbreak of the war restricted the Central Powers, Bulgaria and Turkey to their own resources as to the supply of coin metals and their possible substitutes. Turkey and Bulgaria possess rich mines, but they are not much exploited. The gold and silver mines of Hungary and Transylvania are locally not unimportant, but insignificant, of course, by comparison with those of the British Empire and America. Austria and Germany extract a quite insignificant amount of gold and a little more silver as by-products from other ores. As regards nickel, the whole world practically depends on Canada and New Caledonia. When gold was withdrawn from circulation, the demand for silver coins naturally increased, and the tendency of hoarding money in coin, and not in notes, developed strongly. The German silver coins are still of the same fineness as before the war; to make the silver less attractive, however, the final etching is dispensed with, so that the coins do not look bright, but dull black grey. Nickel served in Germany before the war only as material for the equivalents of the half-penny, penny and multiples of the penny; the 25 pfennig-piece was made of pure nickel, the smaller coins of 75 per cent. of copper with 25 per cent. of alloy. Austria also coined florins of the alloy; Turkey introduced small nickel coins in 1911, when adopting the gold standard; Bulgaria also had nickel coins. In Germany, the nickel is now replaced by iron; the half-penny (5 pfennig) weighs 2·5 grams, just as much as the former nickel coin—they were used for checking the weight of letters—and has a diameter of 17·5 mm.; 400 pieces (aggregate value, 20 marks) are coined from 1 kg. of iron; the 10 pfennig piece has a diameter of 21·3 mm. The material is a tough, very low carbon Siemens Martin steel, of 33·6 per cent. elongation; the mechanical properties have to satisfy certain conditions, but there are no particular specifications as to silicon, phosphorus, &c. To reduce rusting, these pieces are coated with zinc, generally by the Sherard Cowper-Cowles process, after being coined; the practice varies, however, in the six German mints, we see from a communication by Trenkner, of the Berlin mint, in *Metall und Erz*, of March 8, 1918 (pages 68 to 73). The Schoop metal-spraying process was also tried, but it remains in use only for preparing tokens of metal-sprayed paper, which serve as money substitutes in large establishments, camps, &c. Extensive experiments have been conducted on the corrodibility of the sherardised iron coins. They turn yellow-brown in distilled water in 24 hours, but rust much less in ordinary supply-water; the specks of rust, forming mainly along lines in the direction in which the iron was rolled in the mills, can easily be wiped off, even after five days' immersion in the water; bad cases of rusting have occurred, however. In sulphuretted hydrogen the iron turns black, then grey. Soap, ammonia and salt also favour rusting. The observations on the effects of high-temperature are interesting; at glow temperature the zinc escapes from the surface layer of $FeZn_3$, with almost explosive energy, but the die-pattern remains distinct. These high-temperature experiments were made because the money is sometimes kept in the old-fashioned German tile-stoves. The coinage of copper was discontinued in 1917. Aluminium had been coined to a small extent before the war; the smallest coins, 1 and 2 pfennig pieces are now made of aluminium, which is more attacked by ordinary water, soda, salts, &c., than by distilled water. Zinc coins have recently been introduced. Zinc coins had been used in French Indo-China; they are again more apt to corrode, especially when impure with lead, cadmium, and iron, in distilled water than in ordinary water; they turn yellow-brown, but assume a pleasant grey tint in soda and salt. On the whole, the cheapest iron coins have answered best.

Patents, Designs and Trade Marks.

The thirty-fifth report of the Comptroller-General of Patents, Designs and Trade Marks for 1917, states that the receipts for the year amounted to 318,148*l.* 18*s.* 3*d.*, in which total the patent fees enter for a sum of 292,214*l.* 19*s.* Expenditure amounted to 193,721*l.* 15*s.*, the greater part, or 147,493*l.* 5*s.* 2*d.*, being for salaries. The surplus of receipts over expenditure was 124,427*l.* 3*s.* 3*d.*, as compared with 107,492*l.* in 1916. Applications for patents amounted in number to 19,285 (18,602 in 1916); for designs, the number was 13,208 (15,399 in 1916), and for trade marks, 5,502 (5,837 in 1916). During the year, 223 applications were made under the Patents, Designs, and Trade Marks Temporary Acts and Rules for the avoidance or suspension of patent rights. In 178 cases, licenses have been, or will be granted, and in 3 cases the patents have been suspended in favour of the applicants. Of the remaining applications, 2 have been refused, 5 have been withdrawn or abandoned, 5 have been returned as not being required by reason of the patents having been expired, or for some other cause, and the rest have not yet been decided. Nineteen applications for the avoidance or suspension of the registration of trade marks were received. Under the provisions of Section 6 of the Trading With the Enemy Amendment Act, 1916, orders have been made vesting in the custodian the benefit of over 2,000 applications for patents, made by or on behalf of enemy subjects, and patents have been sealed to the Custodian on these applications. During the year, 91 applications for the grant of licenses under such patents were received. Six of these applications were abandoned, and in the remaining cases, licenses have been, or will be, granted. The number of patent specifications sold was 165,772, as compared with 153,243 in 1916. Of the trade marks registered during the year, 331 covered substances used as food; 207 covered perfumery; 177 chemical substances for use in medicine; 171 articles of clothing; 143 chemical substances used in manufactures; 122 were for detergents, oils, etc.; 109 machinery other than agricultural; 106 metal goods not included in other classes. The order and numbers were practically the same in 1916. During the year, 2,744 trade marks were registered, as compared with a total of 2,878 for the preceding year.

Fire Brigades, North Eastern Area.—The Secretary of State for the Home Department has issued an Order, dated July 30, according to which the counties of Northumberland and Durham and the northern portion of the North Riding of Yorkshire are constituted a Special Fire Brigade Area, to be called the North Eastern Fire Brigade Area. The Order specifies in what way the various fire brigades are to co-operate.

INDUSTRIAL NOTES.

The Civil War Workers' Committee, which was appointed by the Ministry of Reconstruction, has now issued its first (interim) report. The Committee was appointed "to consider and report upon the arrangements which should be made for the demobilisation of workers engaged during the war in National Factories, controlled establishments, in other firms engaged in the production of munitions of war and on Government contracts, or in firms where substitute labour has been employed for the duration of the war."

The recommendations contained in the report may be summarised as follows:—

(*a*) Steps should be taken by the Government to assist munition and other workers discharged on the termination of hostilities to return to their former or other employment.

(*b*) The machinery by which this assistance should be given should be the Employment Exchanges working in conjunction with the Labour Resettlement Committee and the Local Advisory Committees, which it is understood are now being constituted by the Ministry of Labour in accordance with the recommendations of the Army Demobilisation Committee.

(*c*) In addition to the Employment Exchanges and the Local Advisory Committees, the advice of industries as a whole should, where necessary, be sought through the Joint Industrial Councils where these exist, or in other cases through the temporary Trade Committees which it is understood are now being set up by the Ministry of Reconstruction, the Board of Trade, and the Ministry of Labour, acting jointly.

(*d*) As soon as there is a reasonable prospect of peace, the Local Advisory Committees and the Employment Exchanges should take steps to ascertain where workers are likely to be required immediately on the termination of the war and what the demands of individual factories are likely to be.

(*e*) By means of the form printed in Appendix A of the Report, registration of individual war workers should be undertaken with a view to facilitating their return to their former employment or finding fresh employment for them. The details of this scheme should be worked out by the Ministry of Labour, care being taken that the assistance of Trade Unions shall be secured.

(*f*) Arrangements should be made in connection with the termination of Government contracts whereby, subject to such exceptions as may be necessary, munition workers should receive a fortnight's notice or a fortnight's wages in lieu of notice, and the provisions of Section 3 of the Munitions of War Act, 1917, should be extended accordingly.

(*g*) Steps should be taken by the Departments concerned to encourage Government Departments, public or semi-public bodies and private employers to place post-war contracts in advance, the contracts being arranged, if necessary, at provisional prices to be adjusted later according to revised estimates of the cost of labour, materials, and other things, or as an alternative, on a profit basis. Similar measures should be taken by the Department of Overseas Trade through their Trade Commissioners and Commercial Attachés abroad.

(*h*) The Government should have in readiness before the end of the war, further schemes to meet the possibility of any local or general unemployment which may prove to be more than of a temporary nature.

Sir Henry Birchenough's Committee on Supplies for Industry after the War recommends that the control of industry be discontinued as early as possible; in the meantime, there should be the least possible interference with private enterprise. Special consideration should be given to industries which provide a large amount of employment. Importance should be attached primarily to industries dealing with—

(*a*) The production of food and raw materials;

(*b*) The manufacture of machinery and equipment which are immediately necessary for the industrial and transport requirements of the country;

(*c*) The manufacture of finished goods for export;

(*d*) The production of goods for home requirements of pressing nature.

The Government, after considering the Committee's proposals, has decided to take immediate action on the lines of the Committee's report and the recommendations of the Minister of Reconstruction. The Government intends that post-war control and allocation of materials shall be applied only in cases where it is absolutely necessary. On the assumption, however, that there will be a shortage of certain commodities, which will render some form of control imperative, arrangements require to be made for dealing with the matter. It is proposed that a small Cabinet Committee on post-war priority shall be set up consisting of the President of the Board of Trade, the Minister of Labour, the Minister of Shipping, the Minister of Munitions, and the Minister of Reconstruction, with the same Chairman as the War Priorities Committee. This Committee will determine large questions of policy, and will lay down general principles upon which any allocation and priority should proceed where necessary. This Cabinet Committee will be assisted by a standing Council composed of members of Departments chiefly concerned, together with persons representative of commerce, industry, and labour. These two bodies will form the central machinery, and will be in close touch with the existing War Priorities Committee.

On the 1st inst., the Minister of Reconstruction met representatives of the principal industrial and commercial organisations at the Central Hall, Westminster, in order to explain the proposals in detail, and ascertain their views as to the most acceptable means of carrying them out. Representatives of Interim Reconstruction Committees of 16 trades, Joint Industrial Councils of 3 trades, Provisional Joint Committees of 18 trades, representatives of 14 branches of the engineering industry, and of other bodies attended the meeting.

The British Engineers' Association, representing the manufacturing engineers of Great Britain, desire to place on record their grave concern at the delay on the part of His Majesty's Government in making public the economic policy which is to be adopted by this country after the war. On behalf of the industry, they urge:—

That it is imperative that His Majesty's Government should make public declaration at once in order that this country may be prepared and properly organised to take its place in the economic struggle which will arise at the close of the war, and for which the enemy countries have been systematically and energetically preparing for some time past. The Association feel very strongly that unless the Government declares its policy, this country will be at a serious disadvantage with competing countries after the war.

The Association recommend:—

1. That preferential treatment shall be given to the British Overseas Dominions, and that Allied and neutral countries shall only be permitted to trade in this country on terms equivalent to those granted to this country by the Allied or neutral country concerned.

2. That for a definite period of years, no enemy subject shall be permitted to trade within this country.

3. That British capital shall be used first and foremost for the development of the resources of the Empire *for* the Empire.

4. That rates of inland rail and water carriage shall be revised to make it impossible for goods from overseas to be delivered at inland points cheaper than home-produced goods.

5. That rates of ocean freights shall be so regulated as to make it impossible for the freight charged on British goods to and from British ports to be greater than that charged to and from foreign ports.

6. That the policy of His Majesty's Government shall be specifically directed to the attainment of these ends.

Lord Hunter, Judge of Appeals under the Munitions Acts, recently issued judgment in an appeal raising questions as to the status of employees of the Clyde Navigation Trustees in relation to the 12½ per cent. advance. The Clyde Trustees were held by the Glasgow General Munitions Tribunal to have failed to comply with an Order made by the Minister of Munitions on October 16, 1917, and guilty of an offence under Section 7 of the Order and Section 1 (4) of the Act of 1915. In this case, the men were the harbour diver, who was a rigger by trade; slaters, men attached to the appellants' civil engineering department, a blacksmith, and a hammerman. The Trustees submitted that these men were not fully qualified skilled engineers and moulders employed on or in connection with munitions work, and were not within the Order, and that the tribunal had no jurisdiction to determine the difference between the parties, which should have been determined by arbitration.

Lord Hunter dismissed the appeal. His Lordship said the Order provided that, as to the remuneration to be paid to fully-qualified skilled engineers and moulders for munitions work, at time rates workmen were to receive a bonus of 12½ per cent. on their earnings as from the first full pay following October 12, 1917. The appellants did not insist on the no jurisdiction plea, and his Lordship thought they were well advised. The question whether these employers, or any of them, were entitled to the bonus as from October, 1917, was one of considerable difficulty. Using the language of the Order in its ordinary sense, he would not say that any of these men were skilled engineers or moulders. The Ministry of Munitions, however, by issuing a circular letter, dated October, 1917, for guidance in the application of the Order in question, must, his Lordship thought, be held to have indicated that, under the term skilled "engineers and moulders," they intended to include many workmen who would not naturally fall under the specified category. The effect of the circular was to extend the Order, and the Clyde Trustees were just as much bound to observe its provisions, in their extended sense, as in their narrower, and, as he thought, more natural sense.

Lord Hunter issued on the same day judgment in another appeal, in which the appellants, Messrs. William Harvie and Co., Limited, 24 M'Alpine-street, Glasgow, were fined 1*l.* for having failed to pay the bonus of 12½ per cent. to certain sheet-metal workers in their employment between October 12, 1917, and January 1, 1918. The employers submitted that they had not been guilty of any contravention because no official award, arrangement, or decision had been issued requiring payment of the bonus to be made to sheet-metal workers or tinsmiths, and because they had not been instructed to pay the bonus.

Lord Hunter recalled the decision of the Glasgow Munitions Tribunal. His Lordship said he was unable in constructing the Order to give the expression "skilled engineers and moulders" the extended significance which the tribunal had attached to it. It remained, however, to be considered whether sheet-metal workers were included in any of the occupations specified in the October circular. His Lordship was unable to find that they were so included. The claim of sheet-metal workers to the bonus was dealt with by the Committee on Production, who, by award, dated February 8, 1918, found that these workers should receive the bonus as from January 1, 1918. The employers had, in fact, paid their sheet-metal workers the bonus as from that date. He did not think they failed to comply with the directions of the Minister of Munitions by not paying the bonus between October 12, 1917, and January 1, 1918.

Speaking at the annual general meeting of the shareholders of the Gloucester Railway Carriage and Wagon Co., Limited, held last week, Sir Richard V. Vassar-Smith, Bart., chairman of directors, said he was pleased to state that the progress of the company during the year had been very satisfactory, and in that connection he wished especially to mention the fact that the men employed in the works had assisted the management whole-heartedly in contributing to that happy result. There had never been any difficulty about that. The men had loyally backed up the efforts of the management in producing the maximum amount of work under great difficulties, and they had shown themselves willing to assist in every way the scheme of dilution which had been introduced into the works under the orders of the Government. He (the chairman) felt it was only right he should point out that it was due very much to the steady, zealous work which had been maintained that the directors were able to place such a satisfactory result before the shareholders as that which was recorded in the report and balance-sheet. The Works Committee continued to be of very great help to the management, constituting as it did a recognised vehicle for communicating to the management any troubles which might arise in the works, and the early attention to such matters which was thus rendered possible prevented unrest spreading, for the men knew that their committee had every opportunity of putting any troubles before the management, and of their receiving prompt attention.

The Minister of Munitions, with the concurrence of the Secretary of State for War and the First Lord of the Admiralty, has appointed a Committee of Inquiry into the Royal Ordnance Factories, Woolwich, with the following terms of reference:—

"To inquire into, and report upon, the control, administration, organisation, lay-out and equipment of the Royal Ordnance Factories at Woolwich, and the nature and distribution of the work carried on in them and at the Arsenal generally, and to advise the Minister of Munitions what, if any, changes are required. The Committee to have due regard to the importance of efficient and economic production, and the necessity for maintaining a reserve of productive power, and to give due weight to the obligations of the Government, as an employer, in order to ensure the best possible industrial and housing conditions for the employees."

The chairman of the Committee is the Rt. Hon. T. McKinnon Wood, M.P.; and the secretaries, Mr. S. H. Leake and Mr. J. Murray, Ministry of Munitions.

"COAL SAVING BY SCIENTIFIC CONTROL OF STEAM BOILER PLANTS."

To the Editor of Engineering.

Sir,—Concerning the articles on "Coal Saving" that appeared in your issues of the 12th and 19th inst., as it is possible that they may share the same fate as their predecessors of 1916, may I be permitted to say a few words.

To me, and no doubt to the authors also, it is a great disappointment that an article on this subject of undoubted merit does not open up a discussion.

As the authors remark, the question of coal economy affects our future progress, and under these circumstances,

too much light cannot be thrown on the subject. May I therefore suggest that a sub-committee of the Engineering Standards Committee should at once set to work on the following items :—

1. Standardise all steam generators.
2. Standardise all boiler fittings.
3. Standardise all boiler settings.

The Board of Trade should also be responsible for the following :—

1. To obtain Parliamentary powers to prevent coal being used in steam generators on and after a date to be determined.
2. To obtain power to forbid the manufacture of certain type of boilers now much in evidence that are impossible to work efficiently.
3. To have power to issue permits to generate steam.

In this connection, any body that may require a permit, must state in full how they propose to carry out the service which must be approved before the permit is issued.

4. Be responsible for all inspection work. This item 4 is essentially a Government duty and the insurance should be compulsory.
5. To compel smoke abatement to be an actual fact, with severe penalties for any infringement.

Concerning the work allocated to the Engineering Standards Committee, if coal is still to be the fuel the boilers could be standardised to advantage, as to me it appears needless to have dozens of draughtsmen all designing various sizes of Lancashire boilers in different parts of England. The fittings also, by being to a standard would be cheaper, and what is very much to the point interchangeable.

Again, where batteries of boilers are at work more fittings are necessary to enable one to know which boiler is not doing its share. For the settings full provision must be arranged for the expansion of the brickwork, and the retention of heat. In this connection a 4½-in. firebrick protection of the concrete mat supporting the boiler is totally inadequate, although approved by the leading boiler insurance societies.

The next point to consider is the removal of the products of combustion, and at the same time supply the requisite amount of air to ensure perfect combustion. To carry out these two items we must know the power required to overcome the resistance through the fuel bed, and the flues. Data on this subject are scarce in England, and I would here recommend any one interested to seek for it in text books from the States. There they have gone into the subject most fully, and there is an abundance of information to be had there.

To me a steam-driven fan of ample power connected to a chimney on the "Prat" system, preferably of the in-circuit type, is the way to handle the job. On no account should steam jets be used, and it is most surprising to find some of our leading boiler-makers still recommending this method.

Referring now to some of the statements made by the authors there are one or two that exception is taken to :—

1. Thirty-five pounds of coal *can easily* be burnt per square foot of grate per hour.

This requires qualifying as it cannot be done in a Lancashire boiler, 21 lb. to 24 lb. being nearer the mark.

2 Some boilers have had their output doubled. They must have been bad.

3. Eight hundred and fifty gallons an hour *can easily* be evaporated in a 30 ft. by 8 ft. diameter Lancashire boiler.

From and at 212 deg. F. presumably ? not otherwise. For hand-firing 8 ft. diameter boilers are too large to stoke efficiently—7 ft. 6 in. is the maximum size that should be used.

4. Economisers are installed in a most rule-of-thumb method.

I don't believe it, and for the benefit of those who have not yet run against it, the following formula will serve, which is used by the Green Fuel Economiser Company, I believe.

Increase in Temperature of Feed Water due to the Use of an Economiser.

Let t_1 = initial feed water in degrees Fahrenheit entering economiser.

t_2 = final feed water in degrees Fahrenheit leaving economiser.

T_1 = initial temperature of flue gases, degrees Fahrenheit.

T_2 = final temperature of flue gases, degrees Fahrenheit.

x = rise in temperature of feed water ($t_2 - t$).

D = algebraic mean temperature difference between feed and flue gas

$$= \frac{(T_1 - t_2) + (T_2 - t_1)}{2}$$

w = pounds of water per boiler horse-power hour (approximately 30).

W = heat of flue gas per boiler horse-power pounds (approximately coal per boiler horse-power × 20).

c = specific heat of flue gas (approximately 0·20).

$w\,x$ = British thermal units absorbed by feed water per boiler horse-power hour.

$c\,W(T_1 - T_2)$ = British thermal units given up by flue gas per boiler horse-power hour.

Then

$$T_1 - T_2 = \frac{w\,x}{c\,W}$$

and

$$D = T_1 - t_1 - x\,\frac{c\,W + w}{2 \cdot c\,W} \quad . \quad . \quad (1)$$

S = square feet of economiser surface per boiler horse-power.

= 3·5 to 5.

U = unit heat transmission of tubes or British thermal units transmitted per square foot per degree difference in mean temperature per hour.

U D S = British thermal units transmitted per hour per boiler horse-power.

$$U\,D\,S = x\,w \quad \therefore \quad S = \frac{x\,w}{U\,D} \quad . \quad . \quad . \quad . \quad (2)$$

Combining (1) and (2) :

$$x = \frac{S\,(T_1 - t_1)}{\frac{w}{U} + \left(\frac{w + c\,W}{2\,c\,W}\right) S} \quad . \quad . \quad (3)$$

Substituting $w = 30$, $c = 0.20$, and $U = 3.3$

$$x = \frac{S\,(T_1 - t_1)}{9.1 + \left(\frac{5\,w + W}{2\,W}\right) S}$$

In conclusion, Mr. Editor, may we hope that the authors will give us their views on how boiler plants should be served to run efficiently ? And it is to be hoped also that we may hear the views of your other readers on the use of surface combustion and pulverised fuel, &c., in relation to coal economy.

I beg to remain, yours faithfully,

July 28, 1918. "MORGAN."

TO THE EDITOR OF ENGINEERING.

SIR,—The thanks of all steam users and the engineering world generally are due to Mr. Brownlie for his very comprehensive report of boiler tests, which appeared in ENGINEERING on July 12 and 19, and was referred to by several correspondents in your issue of the 2nd inst.

Mr. Brownlie gives in his report much useful data, and which, if properly appreciated, will assist the steam user in making a considerable reduction to his coal bill, and naturally also the Government, in keeping all industries in operation even under the coal rationing scheme. Economy, therefore, in this case is the truest patriotism.

In the report referred to 1,000 boilers are included, 935 of which are ordinary Lancashire, the remainder, with the exception of five, also tank boilers, and Mr. Brownlie's figures can, therefore, be taken as representative of existing conditions throughout the country.

Briefly then, existing conditions may be taken as follows, so far as tank boilers are concerned, the average size is 30 ft by 8 ft. ; grate area, 38 sq. ft. ; ratio of heating surface to grate area, 25 to 1 ; coal consumption per foot of grate, 21 lb. ; CO_2 7·6 per cent. ; evaporation per square foot of grate, 137 lb. ; average boiler efficiency, less than 57 per cent.

It is nothing less than a national disgrace that the above state of things should exist in a so-called scientific country, and still one of your correspondents says in his letter last week that the report in question "gives no sound basis for judgment concerning either the extent of the improvement obtainable or as to the lines along which it should be sought," whereas our present crude, glaring, ignorance is shown up in almost every line of Mr. Brownlie's report.

A furnace, 6 ft. long and 3 ft. 2 in. wide, when only burning 20·9 lb. of coal per foot of grate per hour, must be very thin, and, therefore, allows a large amount of excess air, and this is proved by the fact that the average CO_2 in the 1,000 boilers tested was only 7·6 per cent., or equal to 30 lb. of air per pound of coal burned, whereas with a well-managed fire, say, 10 in. to 12 in. thick, there is no difficulty in maintaining the CO_2 indicator at 13 per cent., at which reading the weight of air per pound of coal is 18 lb.

Without going into details, when the products of combustion contain 7·6 per cent., CO_2 over 34 per cent. of the heat value of the coal passes up the chimney, but with 13 per cent. CO_2 less than 21 per cent. of the heat escapes; here then is one of the lines Mr. Brownlie has indicated that we can at once work on with confidence as it shows a clear saving of 14 per cent. possible.

If our 8 ft. diam. Lancashire boilers were fitted with grates 4 ft. long, instead of 6 ft., we could work with thicker fires, secure better combustion, increase our ratio of heating surface to grate from 25 to 1 to 40 to 1, and increase our boiler duty and save not far short of 20 per cent. in fuel.

Mr. Brownlie's report gives the above information by pointing out our present defects.

Yours faithfully,

W. H. CASMEY.

Milnthorpe, Wakefield, August 6, 1918.

TESTING AIR COMPRESSORS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have noted with interest the particulars of test of Belliss and Morcom air compressor, also the recent correspondence. Mr. Tennant's reference to air control, in his letter of the 24th inst., reminds me, however, of a point which struck me when reading the results of the test. I was rather surprised to see that suction throttling was adopted. This method has been abandoned by leading American makers for some years in favour of holding open the suction valves, allowing the air to be drawn in and discharged at practically atmospheric pressure. Whilst great strides have been made in pneumatic engineering in recent years yet it still would seem that English practice follows, not leads. Why do we lag behind ?

Yours faithfully,

W. W. F.

July 30, 1918.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Tennant confesses to having found very little published information regarding air compressors, the reason being, I think, that there is very little to write about, the machine is so very simple. With regard to Mr. Tennant's published test, there is a lack of information, such as the dimensions of the machine, that is supposed to give the results stated, particulars of which I notice another correspondent in your issue of the 19th ult. asks for, and if Mr. Tennant could see his way to publish them, the test would then assume some value. The actual capacity of the compressor is what is wanted, and I hold that that cannot be accurately measured by such a pump-up test, and also that running the test at half-speed is all to the advantage of the machine.

Regarding the surging effect at the inlet, it would be interesting if Mr. Tennant could publish the first stage indicator card, showing the effect of the surge on the suction line. As to the no-load test, I am still in the dark as to how the clearance volume air was got into the second stage cylinder after having been exhausted by the air pump. It might interest Mr. Tennant to know that the best no-load results on any compressor are to be had by closing the air inlet and opening the second-stage cylinder to atmosphere, which method is used by other compressor makers, and, finally, can be say why this particular machine should give better no-load results than another machine of different make, there being no reason, so far as I know, for assuming this.

I remain, yours faithfully,

M. FAIRLEY.

7, Polwarth Crescent, Edinburgh, August 1, 1918.

THE DEFINITION OF HARDNESS.

TO THE EDITOR OF ENGINEERING.

SIR,—Having had a good deal to do with hardened work and having experimented a little on hardness testing, perhaps the following remarks may interest others who are going more thoroughly into the subject.

Considered as a scale, I was much impressed in favour of the scleroscope markings. Hardness 100 corresponds, I think, to about 1 per cent. carbon steel water hardened as well as possible, and like 100 deg. C., indicating boiling water, it seemed easier to mentally grasp the relative figures than the numbers employed by Brinell.

I cannot see, however, that the scleroscope takes into account any other property of the material than its elasticity and speed of recovery. In any case, the instrument fails on such materials as timbers, electrical insulating compounds, and, 'I think, non-metallic substances generally.

Before reading Professor Unwin's valuable article in your issue of May 17, and without being very conversant with Martel's test, I experimented on the lines of measuring the work required to produce a unit volume, viz., 1 cub. mm. of indentation.

In all cases, I took the weight of half a kilogramme and dropped it half a metre. I used various tools, and without knowing that the indentation volumes should be equal, the following results agree with this pretty closely.

Tool H.—Hatchet-shaped with edge longitudinally a segment of 100 mm. diam. circle. Cross-section 90 deg. angle with apex rounded to half a mm. radius.

Tool C.1.—Cone, angle of frustum, 120 deg. ; point rounded to 1 mm. radius.

Tool C. 2½.—Cone, 120 deg., point rounded to 2½ mm. radius.

Tool B.—Ball, 22 mm. diam.

Work expended, ·5 kilo. × 500 m/m. ÷ indentation volume cub. m/m.

Material.	Mild Steel.	Rolled Brass.	Lead.
Tool H.	·65 m/m.³	1·10 m/m.³	13·15 m/m.³
" C.1	·78 "	1·30 "	13·97 "
" C2½	·59 "	1·24 "	12·85 "
" B.	·53 "	0·94 "	12·54 "

Testing with the hatchet tool which, owing to the great variation in the length of cut, gives the most accurately measurable results, and in order, to lower the hardness figures, taking—

$$\frac{\text{Work expended in Centimetre Kilos.}}{\text{Displacement in Cubic mm.}} = \frac{50 \times \cdot 5}{\text{m/m.}^5}$$

I got a scale as follows :—

	Displacement Volume. m/m.⁵	Hardness.
Carbon tool steel hardened ...	·0623	401
Carbon tool tempered straw	·09	278
Carbon tool tempered blue ...	·19	131
Carbon tool from bar normal	·212	118
Carbon tool, annealed ...	·387	65
Mild steel	·64	39
Brass	1·11	23
Copper	1·3	19
Lead	13·0	2

If hardness be defined as resistance to deformation, then as work only can mechanically produce deformation, it seems to me that work is the correct thing to measure it by.

Yours faithfully,

R. M. LESLIE.

88, North-road, Highgate, London, N.6.

August 3, 1918.

THE NEW NAVY OFFICE BUILDING, WASHINGTON.—We read in *The Marine Journal*, New York, that the new Navy Office Building now being erected in Washington, is the largest of its kind in the world. It is three storeys high, covers 42 acres of ground, and will house 15,000 persons. The cost is 5,750,000 dols.

TANTIRON.

The manufacturing chemist and metallurgist are greatly restricted by the limitations of applicability of their apparatus. In many processes, the difficulty is not so much to obtain the raw materials as to find furnaces, containers, pipes, &c., that will bear the chemical and physical stress of the reactions, and to avoid the contamination of the products by the substances with which the reactions bring them into contact. For these reasons many a promising process never gets beyond the laboratory stage; hence, also the cry for substitutes of rare, expensive materials, as well as the natural distrust of them. The enhanced activity of certain chemical industries has much increased the demand for refractory materials and acid-resisting alloys. Experiments with acid-resisting iron alloys are not new, of course. Wollaston made a silicon-iron, and he may not have been the first. Engineers and electricians found silicon-iron very useful for special purposes, and many attempts were made to construct chemical plant of silicon-iron and other iron alloys. Tungsten, chromium and nickel were tried. But foundrymen seemed to be unable to make vessels even of moderate dimensions of such materials, and it was not till 1912 that an acid-resisting iron alloy of sufficient uniformity and strength for the engineer to deal with was put on the market.

It was the tantiron of Mr. R. N. Lennox, made by the Lennox Foundry Company, of Glenville Grove, New Cross, S.E. Since then silicon-iron and other non-corrosive iron alloys have been brought out by several firms. Both the "duriron" of the Duriron Castings Company, of Drayton, Ohio, and the "ironac," of the Houghton Company, of London, are silicon-irons, like the métillures of A. Jouve, one of the first in this field, and the Italian eleanites, which contain about 2 per cent. of nickel. The American rights for tantiron were, in 1913, taken over by the Bethlehem Foundry and Machine Company, Pennsylvania. "Ferrochrome" is supplied by the Electrometallurgical Company of Niagara Falls; the "feralun" is likewise an American product, and German activity in the field will not have ceased during the war; in addition to "neutraleisen" there are ferro-chromes and ferro borons.

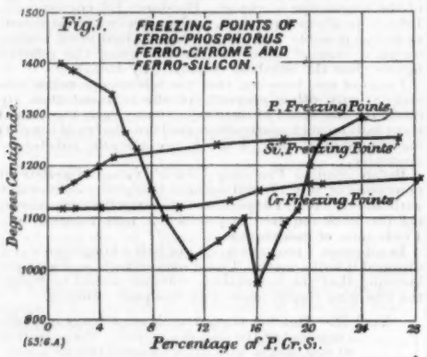


Fig. 2.

That Mr. Robert N. Lennox should have taken up the manufacture of apparatus for the concentration of strong acids was only natural. His father had made sulphuric acid in Glasgow in the days when heavy investments in platinum plant were indispensable for that purpose. When Mr. Lennox started a foundry on his own account, he had for a good many years conducted experimental engineering works of his own, and had, as assistant in the Royal Institution for nearly 25 years, taken his share in Sir James Dewar's low-temperature and high-pressure researches and in the manifold other investigations which are being carried on in the Royal Institution. Extensive well-equipped laboratories are a noteworthy feature of his works.

Tantiron—a fancy name—is a silicon-iron, containing about 15 per cent. of silicon. In appearance it is a silvery-white close-grained cast-iron, and has the general properties of a machinable cast-iron. One special brand of tantiron is very hard, and not machinable; another quality resists hydrochloric acid which the others do not. It melts at about 1,200 deg. C., can be cast, ground with carborundum, cut with the saw, drilled, screw-cut and tapped, &c. So far as chemical and mechanical corrosion is concerned, it is a superior iron and is used for cast vessels or in the shape of linings for those of steel or iron. It does not rust, except at the skin, and the rust is removed by pickling in diluted sulphuric acid or by grinding. The tantiron itself is not—or practically not—attacked by sulphuric, nitric, or acetic acids, concentrated or diluted, boiling or cold, and indeed not by most chemicals. One kind already mentioned—a more recent invention—also resists hydrochloric acid equally well. Carbonic acid attacks it slightly, but the corrosion is only about one-thousandth that of cast-iron. Alkalis corrode it about as much as they do cast-iron; chlorates and perchlorates do not corrode it, and it will resist chlorine gas up to a temperature of 105 deg. C. But sulphur dioxide corrodes tantiron badly. In view of this latter fact, the suitability of tantiron pans and basins for the concentration of sulphuric acid is rather surprising. Large pans have been in use, however, we are informed, since 1912, and some 25,000 basins are actually in use in sulphuric-acid works. There is some slight corrosion, of course, and there are breakages, partly due to the material, partly to improper treatment by unskilled labour, which causes many small and large accidents in these days of rapid plant erection and high-pressure activity. The maintenance cost of pans and basins is about 2½*d.* or 3*d.* per ton of acid concentrated. After boiling 100 grams of the alloy for 17 hours, 10 per cent. sulphuric acid was found to have dissolved 0·13 gram of tantiron, 25 per cent. nitric acid, 0·25 gram, and 30 per cent. hydrochloric acid, 0·16 gram.

The terms "non-corrodible and acid-resisting iron," are misleading, as all such general terms are. Every chemist knows that he must not allow metals to glow in his platinum crucible, as they would form fusible platinum alloys, and that caustic alkalis and certain alkali salts, and even the sooty flame of the gas burner, will ruin his crucible. Tantiron also has its peculiar weaknesses. It resists hot sulphuric acid much better than cold acid, and many instances of attack are so far inexplicable. In one case, a tantiron tower containing vapours from boiling sulphuric acid showed defects in the top sections, without any attacks on the bottom sections. The top sections were replaced several times; the bottom sections, which had been in use for eighteen months, were taken out and inserted in the top, when they were attacked within a fortnight; yet temperature determinations at different points of the tower never showed differences exceeding 5 deg. C. In other cases, sulphuric acid, are being carefully freed from arsenic by sulphuretted hydrogen, attacked the tantiron nearly three times as quickly as the original acid. But the amount of attack is, of course, exceedingly small. A tantiron vessel weighing 4,950 grams, had 600 tons of sulphuric acid passed through it during concentration with a total loss of weight of 12 gram. The attack is mainly on the surface or skin, which should, therefore, be removed when corrosion tests are conducted.

Though the iron carbide seems chiefly to be attacked, the corrosion is, apparently, uniform; under the microscope, acid-corroded tantiron keeps its smooth surface, while cast-iron shows irregular corrosion. Mr. Lennox prefers to have no carbon in the iron at all. His raw materials are cast-iron, scrap, and old tantiron, and further ferro-silicon. The latter is obtained with about 12 per cent. silicon from Middlesbrough, and in a 50 per cent. grade from Norway. The average composition of tantiron is in per cent.: silicon, 14 per cent. or 15 per cent.; total, carbon, from 0·20 per cent. to 0·60 per cent.; manganese, 0·25 per cent. to 0·35 per cent.; phosphorus, 0·16 per cent. to 0·20 per cent.; sulphur, under 0·05 per cent. The three kinds mentioned, machinable tantiron, hard tantiron and tantiron for hydrochloric acid, differ little in composition, but the small fractions of additional constituents are very important. To study their influence, ingots are poured from furnace charges of 1 ton, to which additions are made in very small increments; the ingots are then tested chemically and mechanically. The sulphur and manganese, in their percentages, seem to be of no consequence. The phosphorus is deleterious, mainly probably because it is not uniformly distributed, but concentrated in spots. As phosphorus is added to iron, the freezing point is first lowered, and then, when 10 per cent. of phosphorus are exceeded, rises again, but the cooling curves are not regular, whilst the freezing point curves of silicon-iron and chrome-iron show a very slow, but steady rise with increasing percentages of those elements. (See Fig. 1.) Impact tests are made on ¾-in. square bars, which are not notched; they break, *e.g.*, under stresses of from 8 ft.-lb. to 10 ft.-lb., against 12 ft.-lb. to 14 ft.-lb. in the case of cast-iron. On the whole, the strength of tantiron is about 25 per cent. smaller than that of cast-iron. The following is a summary of the comparative properties of tantiron and cast-iron (the latter figures in brackets): Density, 6·8 to 7·0 (7·3); tensile strength, 6 to 7 (9 to 10) tons per sq. in.; transverse strength, bars of 12 in. by 1 in., 1,600 lb. (2,500 lb.); crushing strength per inch cube, 34 (40 tons); melting point, 1,200 (1,150) deg. C. hardness, 1·6 (1); heat conductivity, 8 (10); electrical resistance, 10 (8); resistance to corrosion, 1,000 (1); contraction allowance in casting, $\frac{1}{8}$ ($\frac{1}{4}$) in per ft. As regards other properties, also of other materials, the comparative order for iron, tantiron, lead, quartz, stoneware is: Transmission of heat, 230, 215, 115, 28, 20; hardness, 24, 35, 1, 52, 32; density, 7·3, 7, 11·3, 2·6, 2·0; melting point, 1,150, 1,200, 335, 1,900, 1,800 deg. C.

With respect to corrosion by chemicals, there is generally a first attack, followed by relative immunity under continued exposure. The following figures indicate the percentage losses of tantiron after boiling for 24, 48, 72 hours; the greater action during the first 24 hours is largely due to the already-mentioned skin effect, the outer surface having been changed by contact with the sand in which the tantiron is cast; this skin is removed in the foundry, as we stated.

—	First 24 Hours.	Second 24 Hours.	Third 24 Hours.
Sulphuric acid, 98 per cent.	·10	·02	·02
,, ,, 30 per cent.	·07	·00	·00
Nitric acid, 1·4	·03	·01	·00
,, 1·1	·01	·00	·00
Acetic acid, 60 per cent. ..	·03	·01	·00
Chromic acid, 10 per cent ..	·07	·00	·00
Tartaric acid, 25 per cent. ..	·05	·03	·03
Iodine (sat. sol.)	·00	·00	·00
Bromine water (sat.) ..	·01	·01	·00
Bleaching powder (sat. sol.)	·04	·01	·01
Copper sulphate (acid sol.) ..	·00	·00	·00
,, ,, (alkaline) ..	·00	·00	·00
Ferric sulphate (sol.) ..	·08	·00	·00
Zinc chloride, 30 per cent. ..	·03	·00	·00
Ammonium chloride sol. ..	·05	·02	·01
Fused sulphur	·06	·01	·00
Fused nitrate of ammonia ..	·00	-	·00

To meet the peculiarities of the material, it is desirable that designers of parts to be made in tantiron should bear the following rules in mind: large flat surfaces should be avoided, corners be rounded; slots be used by preference to bolt holes; facing strips be narrow and of ample height; the effects of expansion and contraction should be well-considered; coreing and moulding be made easy, by preference without the use of chaplets to support cores. Among the chief products now made wholly or partly of tantiron, are: acid pans, basins, stills, bleachers, denitrating towers, autoclaves, condensers, pumps, stop cocks, valves, pipes and fittings, electrodes, &c. Frequently a tantiron lining will suffice to prevent either chemical or mechanical erosion. The largest tantiron casting so far constructed weighed 7½ tons.

The greatest care is bestowed upon clean moulding, which is mostly done by women, and use is made of rotating strickles in preparing the moulds for parts of circular section. For lining pipes with tantiron, the pipe must be suspended vertically by a flange with the core in proper position, the pipe to be lined being weighted below; if the liquid tantiron were poured into a horizontal pipe, the pipe would curve. This practice is generally adopted for lining iron or steel,

wherever possible, and the part to be lined is well dried, but not pre-heated. The adhesion between the iron and the tantiron is said to be good, fusion taking place between the surfaces; the adhesion is tested with the aid of paraffin oil. The lining may have a thickness from ¼ in. up to 1¼ in. and more. The subsequent finishing of the product is largely done with the aid of carborundum wheels and grinders. It is rather curious that the fine tantiron particles torn off by the tools do not spark; there is only a glow. Drills, saws and planers are also used.

The basins for the heating and concentration of sulphuric are mostly of the plain porcelain dish style, but

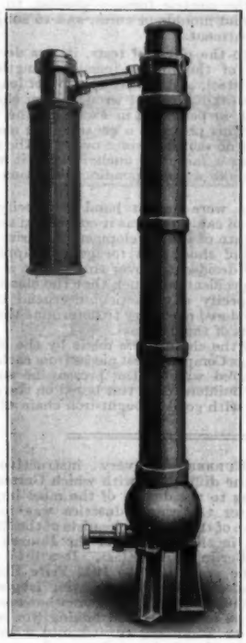


FIG. 3.

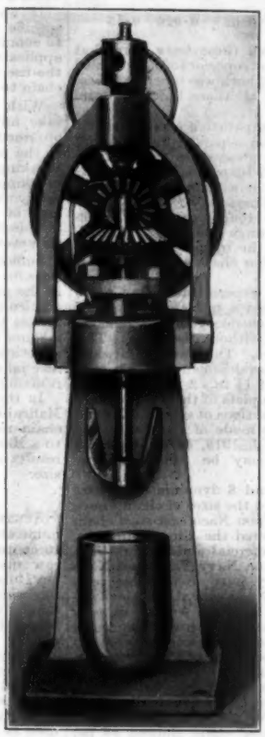


FIG. 4.

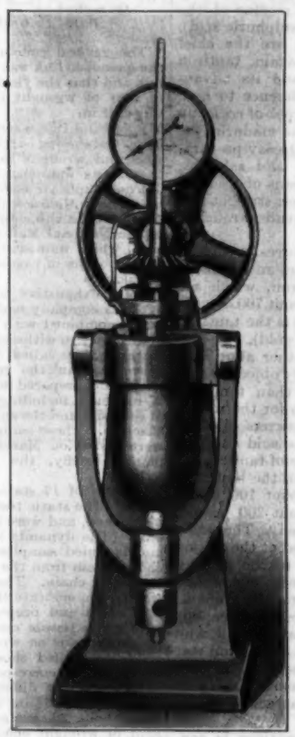
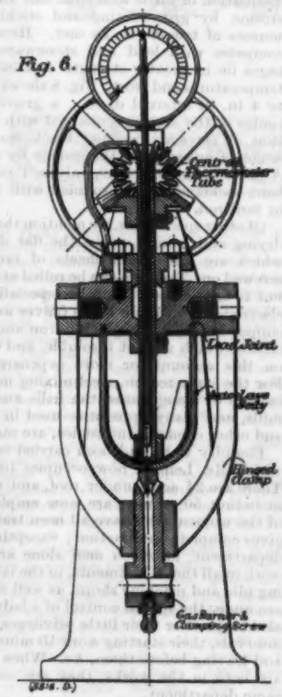
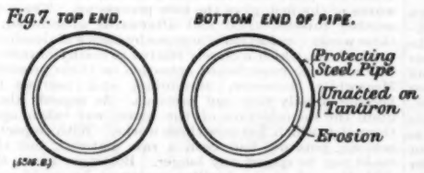


FIG. 5.





tillation. There may also be small globules of oily nitroglycerin which might coalesce if the evaporation were carried on in pans. The tower, 15 ft. high, is built up of socket pipes, 14 in. diameter, and is packed with quartz fragments; the acid enters at the top and steam at the bottom, and the nitric acid and vapours condense in the cylinder by the side of the tower. Nitric-acid stills are also used for the distillation of acetic acid. The autoclaves for making ammonium nitrate from cyanamide at a temperature of 120 deg. C. and a pressure of about 2 atmospheres, resemble one style of nitric-acid retorts. The outer vessel is a jacket of cast iron, the inner vessel of

Acid eggs, apparatus for forcing up corrosive liquids with the aid of compressed air, are made of two tantiron cups, joined by their top flanges so as to form a horizontal cylinder with spherical ends and one common flange on the vertical middle plane; they are provided with acid inlet and outlet valves and an air pipe, and are supplied in large sizes. The pumps of the works, reciprocating and centrifugal, do not differ much in appearance from ordinary pumps; the barrels and impellers and pipes are made of tantiron or lined with it. As these parts of hard tantiron cannot be machined or repaired, it is recommended to keep spare parts ready for cases of accident. Centrifugal pumps

are provided both with a lip and an arc-shaped baffle (not shown); they are supplied also in the Webb and Dyson styles (Fig. 2). The basins are arranged in cascade, so that the hot acid drips from the lips of one basin into the one next below, and the baffle prevents the acid from streaming right over the basins to the lip. Provision for more efficient circulation and stirring of the acid in the basin is made in the "Mackenzie field tube evaporator basins," also supplied by Mr. Lennox; this style has calix shape, being a tube opening out into a basin; a "field" tube fits concentrically into the cylindrical portion and promotes active circulation. Other basins are provided with covers and necks, and made corrugated, and they serve generally also for the concentration of corrosive liquids, such as zinc chloride, lead nitrate, &c.

The concentration of nitric acid requires more varied apparatus, which have successfully been made of stoneware in the past few decades. When the war broke out, the stoneware works of this country were not able to deal with the demands, and tantiron vessels, which can be made in a few days, whilst good stoneware requires months, were largely adopted. Valentiner plants comprising a still, condenser and coils, built up of pipes and return bends flanged together, all of tantiron, are now made. The denitrating tower illustrated in Fig. 3 is an interesting novelty. The spent acid of nitroglycerin works consists of diluted sulphuric acid, which has to be concentrated again, and some nitric acid, which is to be regained by dis-

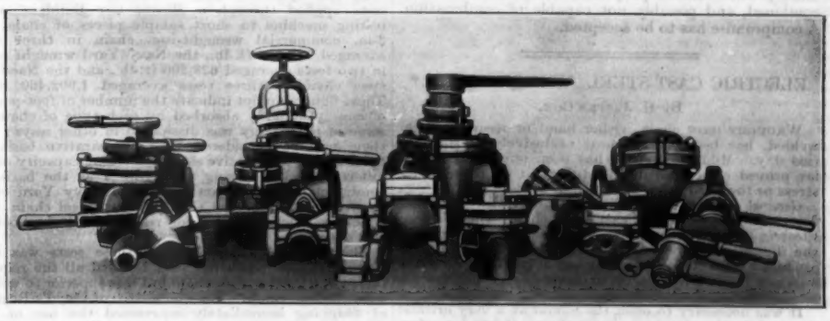


FIG. 8.

tantiron forms the saturator; the height is 8½ ft., and the diameter 4½ ft., *e.g.*

The autoclave illustrated in Figs. 4, 5 and 6, is a clever compact laboratory apparatus, whose utility and handiness will appeal to every chemist. The ordinary autoclave has to be screwed up tightly and unscrewed again each time. In this Lennox autoclave the parts are clamped and unclamped by the use of one spanner, and everything, crucible or cup, stirrer, pressure gauge, burner, is ready for use. In Fig. 4, the cup is seen on its stand open, and the stirrup clamp is turned up. When the cup of tantiron is lifted, and the clamp turned down, the cup is pressed against the lead joint in the cover (Figs. 5 and 6), and the autoclave is sealed; the bolt passing through the clamp, by means of which the autoclave is tightened up, also serves as the gas burner, and the axial stem of the stirrer is hollow to receive a thermometer; the stirrer is actuated by an electric motor.

are supplied for lifting 6,000 gals. of acid or corrosive mine water, &c., per hour, against a head of 50 ft., running at 1,600 r.p.m. Slime pumps, *e.g.*, for conveying the crushed quartz in gold mines are likewise made of tantiron, to obviate the heavy erosion of the pipes by the gritty quartz particles. For the same reason, tantiron-lined steel pipes are used in the Rand mines, South Africa, for the sand-filling plant. When the pillars left in the galleries below are to be removed, the galleries have to be refilled with the finely crushed quartz from the vast white waste mounds which form a conspicuous feature of the district. The spoil is flushed down the pipes with water. The first pipes used, steel pipes, were ruined by 6,000 tons of sand; porcelain-lined pipes were then tried, which could stand up to 50,000 tons; the tantiron pipes, introduced four years ago, are still doing duty, and their life capacity is estimated at 500,000 tons. The 500 ft. of 5-in. pipes put in were delivered in sections of 7 ft. Fig. 7, illus-

trates the erosion they had undergone by the passage of 106,000 tons of quartz sand under a head of 500 ft. In each case the outer ring represents the steel pipe, the second, intermediate ring, the tantiron remaining intact, and the inner ring the eroded thickness. The erosion is greater at the top, where the sand strikes the pipe than at the bottom, and is not the same in all sections, probably owing to peculiarities of their positions. Similarly-lined steel pipes and tantiron pipes, up to 2 ft. in diam., are in use for ash ejectors, especially on board ship, where heavy erosion and corrosion by the caustic ashes and the sea water have to be guarded against.

In stop cocks and valves of tantiron corrosion by acid sodium bisulphate (the acid cake residue of the distillation of nitric acid from salt and sulphuric acid), erosion by grit, rusting and sticking are the chief sources of trouble to be met. Here, again, tantiron competes with lead and stoneware, and its advantages lie in greater strength and indifference to high temperatures and frost. Fig. 8 shows types of cocks up to 4 in. in internal diam.; a groove is made in the centre of the cock and charged with a greasy preparation of ceresin, vaseline, black lead, and asbestos, which is pressed into the groove by means of a screw. A great variety of cocks, valves, T-pieces, straight and bent socketed pipes, provided with threads, are made in tantiron.

Of other specialities, we mention the corrosive-vapour drying and baking ovens, the flat doors and walls of which are lined with sheets of tantiron, which are screwed on. Tantiron can be rolled at about 700 deg. C., but is brittle then. Another speciality is the tantiron electrode for cyanide baths (silver and gold), and also copper baths, &c., replacing iron and other alloy electrodes, which are not insoluble, and very objectionable on this account, or more expensive than tantiron. For the same reason, steel-mixing mills for the manufacture of manganates, the balls and stirrers of other mills, and many apparatus used in the acid and dye and other chemical industries, are made of tantiron.

Foundry work had been carried on in the buildings which Mr. Lennox now occupies for over 100 years. There are 2½ acres under roof, and about 200 people, including 50 women are now employed. The work of the women, who have all been trained at the works, gives complete satisfaction; excepting in the pouring department, in which men alone are employed, they work in all the departments, in the laboratories, moulding pits and machine shops, as well as in the office, but are under the special control of a lady on the staff, who also looks after their little privileges as to tea and rest intervals, their starting work 10 minutes after the men, and leaving before them, &c. When husband and wife are both in the works, they are not attached to the same department.

Like every manufactured article, tantiron is constantly being improved, and does not claim to have reached final perfection. Acid-resisting materials must possess various properties which are not easily combined, and possibly not capable of combination. A compromise has to be accepted.

ELECTRIC CAST-STEEL ANCHOR CHAIN.*

By H. Jasper Cox.

Wrought-iron chain, either hand or steam-hammer welded, has been used almost exclusively in ships to this day. Mild steel chain has been tried, but has so far proved either too ductile to retain its form under stress or too hard to ensure reliable welds.

General Electric Company's Experiments.—In their first attempt to make cast-steel chain, the General Electric Company used electric furnace steel, adopting the die-casting process with metal moulds. The links produced were perfectly sound and of good finish, but it was not found practicable to develop this process for commercial production for the following reasons:—

It was necessary to open the mould at a very critical time, while the metal was congealing; if left for a few seconds longer the links broke, due to the core being solid. If the mould was opened too quickly, the link being in a plastic state tended to deform.

They then made a considerable amount of chain, using sand moulds and cores, experimented with heat treatment and photomicrographs, and eventually obtained links which pulled at from 60 per cent. to 100 per cent. above wrought-iron chain. The first of these links were tested at the Bureau of Standards, and some further samples were tested at a later date at the Charleston Navy Yard. In the latter tests six cast-steel links, 2 in. in diameter, were used; three of the links had been annealed at 850 deg. C. and cooled in the furnace, and three links had been heated to 850 deg. C. and quenched in water. The links were tested in an 800,000-lb. chain-testing machine with the average results set forth in the next column.

Before testing, each link was subjected to a proof stress of 145,400 lb., and none of the links showed a measurable elongation. The diameter was slightly less than 2 in. and the original length 11½ in.

Average of Three Links.	Breaking Strength. Lb.	Total Stretch. In.
Annealed	324,083	1⅞
Quenched	329,750	1½

Note.—The breaking test for a 2-in. wrought-iron chain is 225,792 lb.

The chemical analyses made from composite drillings taken from the links were:—

	Carbon.	Manganese.	Phosphorus.	Sulphur.	Silicon.
	p.c.	p.c.	p.c.	p.c.	p.c.
Annealed links...	0·32	0·55	0·034	0·025	0·14
Quenched links...	0·35	0·68	0·027	0·026	0·15

The general conclusions from these tests were that the quenched link was somewhat superior to the annealed link and that the yield-point of both was much in excess of that of wrought iron. In all these links the stud was cast in.

Following this a series of comparative percussion and bend tests were carried out on separate links of cast steel and wrought iron. The general conclusion from these tests was that they had little relative value, or did not duplicate conditions met with in service.

National Malleable Castings Company's Experiments.—At this time the subject was brought to the attention of the National Malleable Castings Company, of Cleveland, which immediately saw the resemblance between the problems of cast-steel anchor chain and car-coupler knuckles.

After exhaustive tests and experiments some years ago this company had developed a special electric steel which combined with a high tensile strength a remarkable ability to withstand shock without distortion. This material they called Naco steel. They were invited to participate in the further development of cast-steel chain and prepared samples of 1¾ in., 2 in., 2¼ in. and 2⅞ in. chain, including both couplets of the common link of each size and the end combinations of special links and shackles. These samples were made of Naco steel and were tested on March 1 and 2, 1918, at their Sharon plant. Briefly, the results may be summarised as follows:

A total of 17 static tests and 8 dynamic tests were made. The static tests covered the sizes of chain above mentioned, and were largely upon Naco cast-steel chain only. The dynamic tests covered the 2-in. chain only, and included samples of commercial and wrought-iron chain, chain from the Charleston Navy Yard, and Naco cast-steel chain. The primary purpose of these tests was to demonstrate that the Naco cast steel, when put into chain and properly heat treated, would not only give static tensile results in excess of present specified breaking loads on wrought chain, but would withstand suddenly-applied shock stresses better than wrought-iron chains of corresponding sizes.

Of the four different sizes of Naco chain tested statically, the 1¾-in. chain showed an average breaking load about 73 per cent. above the specified breaking load of wrought chain, the 2-in. chain showed 86 per cent., the 2¼-in. showed 75 per cent., and the 2¾-in. showed 77 per cent., or an average improvement of about 78 per cent.

In the dynamic tests, consisting of tensile shock tests applied through a Master Car Builders' drop-testing machine to short sample pieces of chain, the 2-in. commercial wrought-iron chain in three tests averaged 142,680 ft.-lb., the Navy Yard wrought chain in two tests averaged 623,200 ft.-lb., and the Naco test steel chain in three tests averaged 1,902,400 ft.-lb. These figures do not indicate the number of foot-pounds of energy actually absorbed by each type of chain, as some of the energy was dissipated in other ways; but they may be considered as a comparative basis for determining the relative shock-absorbing capacity of the different chains. Using the figure 1 as the basis for commercial wrought-iron chain, the Navy Yard chain showed 4·3 times, and the Naco cast-steel chain 13·2 times as much capacity for resisting a jerk shock of this nature.

The general conclusion from these tests was that Naco cast-steel chain not only fulfilled all the requirements of a good anchor chain but was superior to welded wrought-iron chain. The Committee of Lloyd's Register of Shipping immediately sanctioned the use of this chain on classed vessels and the Emergency Fleet Corporation has ordered a considerable quantity for their new tonnage.

Moulding and Casting Links.—A number of successful moulding and casting methods have been tried, by some of which alternate links are precast and inserted in the moulds before casting the connecting links; in others all links may be cast at one time; while other methods again are adaptable to either.

A good deal of controversy has arisen regarding the respective merits of gating on the stud or on the side of the link, but it may be said that good links have been produced by either. The stud being the least important part of the link, any defect caused at the gate is not of the same importance as it would be on the side.

It is considered most desirable that only dry sand moulds and cores be used, in order to avoid as far as possible the tendency of piping in the casting, especially in the smaller links.

Heat Treatment.—The Naco cast-steel links were subjected to the same heat treatment as Naco car-coupler knuckles. In this treatment the links were placed on a traveller and slowly passed through a heating furnace in which the desired heat is automatically controlled by special contracting pyrometers. At the discharge end of this furnace the links are dropped into a quenching tank of water and after quenching are slowly passed through a drawing furnace on a second traveller.

For the treatment of complete lengths of 15 fathoms of cable modifications in the arrangements of these furnaces and quenching tanks will, of course, have to be made, but it is understood that this has already been worked out by the National Malleable Castings Company.

Specifications.—Following the first series of tests at Sharon, Lloyd's Register of Shipping prepared specifications of requirements for electric cast-steel anchor chain intended to be used in classed vessels, and these specifications with some slight revision have been submitted to Committee A-1 on steel of the American Society for Testing Materials.

It was not considered desirable to lay down any specific requirements with regard to manufacture, but to commence with it was thought necessary to limit the application to the electric furnace process, to require the use of dry sand moulds or cores, and to subject the chain to heat treatment.

With regard to the physical tests, it was decided to take advantage of the higher tensile strength easily obtained in cast steel, and to specify a proof load equal to the present breaking load of wrought-iron chain and breaking load of 40 per cent. in excess of the present breaking load. This provided a considerable margin of safety at little or no sacrifice, since owing to the importance of weight as a factor in anchor chain it was not permissible to make a corresponding reduction in the diameter.

Sufficient data were not at hand to specify shock tests for all sizes of cable, nor was it considered necessary in the present state of the development to insist on any particular form of shock test for general application. It was therefore decided to cover this test in a general manner in the specifications, such that the classification societies may specify any particular crucial or commercial test considered necessary to determine the shock-resisting qualities of the material.

In the case of the chain to be made by the National Malleable Castings Company, test pieces from each shot of chain manufactured will for the present be subjected to a Master Car Builders' drop test based on the average results obtained with good wrought-iron chain of similar size.

* Paper read before the American Society for Testing Materials.

Synthetic Rubber.—A very instructive communication on the difficulties with which Germany has to contend owing to the dearth of the most important raw materials for the war industries was made by Dr. Duisberg, one of the leading chemists of the Elberfeld Farbenfabriken, in the meeting of the Bunsen Gesellschaft, held at Berlin in April last. It will be remembered that in the years 1910 to 1912 Fritz Hoffmann, of that firm, had succeeded in preparing isoprene and dimethylbutadiene, hydrocarbons somewhat resembling benzene, which on long-continued boiling (for weeks or months, it is now admitted) turned into a substance which showed the chemical reactions and some of the properties of caoutchouc. This synthetic product was used as a rubber substitute or as addition to rubber, and the process seemed commercially possible in those days when rubber was in Germany 30 marks per kilogramme. When the price went down to 4 marks, the Leverkusen works of the firm gave the new process up. There was another process, tried and afterwards abandoned, in these works: reduction of acetone by means of aluminium to pinakone, which is closely related to methylbutadiene. The war once more forced attention on these processes. Meanwhile, however, aluminium and acetone had become equally rare and precious. As regards aluminium the manufacture of the metal was taken up in Germany, which has now three works. With respect to acetone, potatoes had been a raw material, but they could not be spared any longer. Böttinger found that with the aid of the bacillus macerans he could make acetone from putrid potatoes, the fermentation yielding a mixture of about two parts of alcohol and one part of acetone; but the bacillus proved very sensitive, and the process was not a success on a large scale. Calcium carbide was then utilised to a larger extent than before the war; it yields, with water, acetylene which in the presence of a contact substance (mercury salts) is converted into acetaldehyde; the aldehyde can be oxidised to acetic acid; blown over another contact substance the acid loses the elements of CO_2, turning into acetone. This process is worked at Leverkusen, at Höchst and at Burghausen on the Alz. The rubber manufacture was then resumed. The rubber industry was not favourably disposed to the new methyl caoutchouc, however, which was not real rubber, absorbed oxygen from the air, and gave trouble in the vulcanisers. This trouble was overcome by the aid of piperidin and other ingredients. The new hard rubber (ebonite) so improved was equal to the old product and dielectrically even stronger; the accumulator boxes of the U-boats are made of this, ebonite. The soft rubber, however, was not perfect yet; at ordinary temperature it resembled leather more than rubber, and became elastic only when warm. The addition of dimethylaniline and of toluidine—both valuable products, it need not be pointed out—cured these defects. In the improved condition the rubber is used for making the tyres for heavy motor vehicles and also for artificial teeth. The Leverkusen works can now supply 2,000 tons of rubber per year, which is about one-eighth of the amount of rubber wanted. Meanwhile Merling has prepared isoprene from acetylene and acetone, and that process, though still in the experimental stage, is also regarded as promising. As to the outlook for these synthetic rubbers in normal times Dr. Duisberg was guarded.

THE MANUFACTURE OF CAST STEEL CHAINS.*

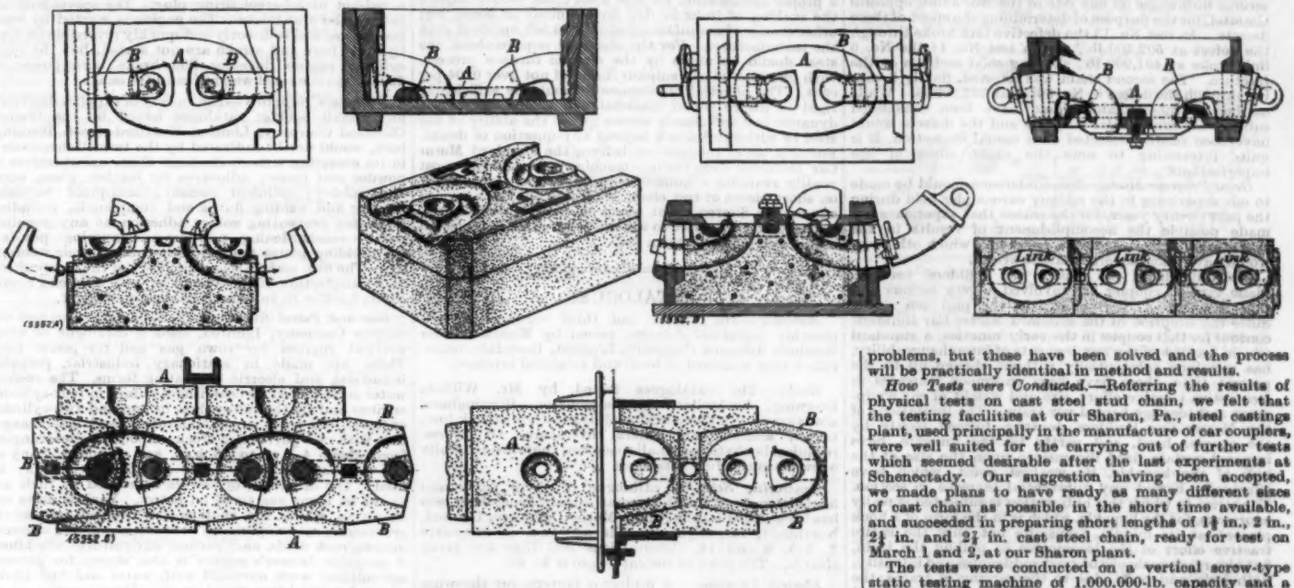
By CHESTER K. BROOKS, Assistant to President, National Malleable Castings Company.

SEVERAL months ago, when the National Malleable Castings Company was invited to participate in the experimental development of cast steel chain, the first problem which required attention was the working out of suitable foundry methods for producing chain links in sand moulds, and uniting them into continuous lengths of chain. A number of entirely successful equipments for making the moulds was the result, four of which are shown above.

Connecting up the links into chain was accomplished in either of two ways, the continuous process, in which the entire chain is poured from one heat, into previously prepared and united moulds, by filling one interlinked mould impression after another, and the pre-cast link process, in which half the links comprising a complete length of chain are cast separately, shaken out, cleaned, inspected, and made ready for incorporation into the finished chain. Subsequently, the latter links are placed in mould cavities and coupled up into continuous chain by pouring metal into other moulds containing impressions for similar links, interlinked with the pre-cast links. Any of the illustrated methods of making moulds is equally applicable to the continuous process or the pre-cast link process.

Another part of the foundry problem was the character of the mould. Recognising the vital importance of sound castings in a product of this character, we came to the conclusion quite early in our experiments that all of the links should be produced in dry sand moulds. The methods of application of gates and risers have also required some study, and we have been able to obtain excellent results both in pouring through the stud and through the side of the link.

In our preparations for manufacture, the adaptation of the method of heat treatment used for our car-coupler knuckles to 90-ft. shots of chain has involved some problems, but these have been solved and the process will be practically identical in method and results.



How Tests were Conducted.—Referring the results of physical tests on cast steel stud chain, we felt that the testing facilities at our Sharon, Pa., steel castings plant, used principally in the manufacture of car couplers, were well suited for the carrying out of further tests which seemed desirable after the last experiments at Schenectady. Our suggestion having been accepted, we made plans to have ready as many different sizes of cast chain as possible in the short time available, and succeeded in preparing short lengths of 1¼ in., 2 in., 2¼ in. and 2½ in. cast steel chain, ready for test on March 1 and 2, at our Sharon plant.

The tests were conducted on a vertical screw-type static testing machine of 1,000,000-lb. capacity and a standard master car builders' drop-testing machine. The chains subjected to static tension tests were supported by coupling each end link of the test chain to the cross-head of the static testing machine by means of a testing shackle and pin.

Test chains consisting of five common stud links were subjected to a light load sufficient to reduce high bearing spots between adjacent links, which was then released and a measurement over the three middle links laid off. The elongation over this measurement was then taken at load corresponding to the proof load, the breaking load, and the breaking load plus 40 per cent., as specified by the ship classification societies for the corresponding sizes of wrought chain. After these three loads had been applied, released, and elongation measured, a load of destruction was then applied.

Dynamic Tests Made.—The test chains used in the drop-testing machine were all of the 2-in. size and consisted of five stud links each. These chains were installed in the testing machine by connecting the upper link in a shackle bar and the lower link in an equaliser shackle by means of shackle pins passing through the eye of each link. This arrangement is such that a part of the energy of the falling weight is transmitted to the test chain as a dynamic tensile stress. The overall measurement of the middle three links of these test chains was laid off as in the static tests and the elongation measured after the third blow from each of the specified heights. The weight of the tup was 1,640 lb. and this weight was allowed to rest upon the equaliser when readings were laid out and elongation measured. In all these tests the numbering of the links was upward, commencing with the bottom link as No. 1.

Table I shows the results of all the static tension tests and Table II the results of the dynamic tension tests. Included among the dynamic tests are not only the tests of 2-in. National Malleable Castings Company steel chain, but also certain tests on the same size specimens of commercial wrought-iron chain, and samples from the Boston navy yard. The following details of the tests are of especial interest:—

Results of Dynamic Tests.—In dynamic test No. 4, on 2-in. Naco steel chain, the chain was subjected to three blows at 5 ft., three at 10 ft., three at 15 ft., three at 20 ft., 50 at 25 ft. and 20 at 30 ft. The chain showed no signs of failure after this severe treatment, and the elongation over the links measured 0·65 in. This chain was then transferred from the drop to the static machine and subjected to the proof load, breaking load, and breaking load plus 40 per cent., after which the load was increased to 452,700 lb., when the No. 2 link broke, showing solid sections at the fracture.

In dynamic test No. 7, on 2-in. Naco steel chain, the chain was subjected to three blows at 5 ft., three at 10 ft., three at 15 ft., three at 20 ft., 10 at 25 ft., 10 at 30 ft., and 10 at 35 ft. The elongation over three links was 0·72 in. with no signs of fracture, after which the chain was submitted to the same static loads as test No. 4, and broke through No. 3 link at 467,400 lb., showing solid metal at the fracture but with a small shrink at one side.

In dynamic test No. 6, on 2-in. navy chain, the chain was subjected to three blows at 5 ft., three at 10 ft., three at 15 ft., three at 20 ft., 10 at 25 ft., and two at 30 ft.

The test was discontinued at this point because of excessive elongation in the chain, which permitted the equaliser to interfere with its support and made it

TABLE I.—STATIC TENSION TESTS OF CHAIN.

Test No.	Size.	Weight of Test Chain.	Elongation in., after Proof Load.	Elongation in., after Breaking Load.	Elongation in., after Breaking Load Plus 40 per Cent.	Load at Rupture.	Remarks.
	in.	lb.				lb.	
1	1¼	40	0·03	0·04	0·08	213,600	Broke No. 3 link. Section of metal solid.
2	1¼	40	0·03	0·04	0·07	198,700	Broke No. 3 link. Section of metal few small blow holes.
3	1¼	40	0·02	0·04	0·09	180,700	Broke No. 3 link. Section of metal honey-combed.
4	2	123	0·03	0·06	0·13	456,400	Broke No. 4 link. Small shrinkage in each fracture.
5	2	122	0·03	0·06	0·09	400,000	Broke No. 3 link. Section shows solid.
6	2	122	0·03	0·05	0·10	403,000	Broke No. 4 link. Section shows solid.
7	2	225	0·20	0·27	0·45	381,900	Broke top "E" link. Section shows few small blowholes.
8	2	223	0·10	0·22	0·63	346,500	Broke bottom "E" link. Section shows few small blowholes.
9	2	223	0·07	0·14	Not obtained	316,100	Broke bottom "E" link. Section shows few small blowholes.
10	2¼	174	0·05	0·09	0·20	494,400	Broke No. 1 link. Section shows solid.
11	2¼	174	0·07	0·13	0·33	495,400	Broke No. 3 link. Section shows solid.
12	2¼	175	0·06	0·11	0·22	513,200	Broke No. 5 link. Section shows solid.
13	2¼	172	0·02	0·05	0·14	502,400	Broke No. 3 link. Fractured through defect.
14	2¼	171	0·03	0·07	0·16	491,900	Broke No. 5 link. No. 3 link defective.
15	2	—	0·05	0·05	0·07	452,700	Broke No. 2 link. Section shows solid. See also dynamic test No. 4.
16	2½	251	0·00	0·00	0·00	764,700	Broke "E" link. Section shows few small blowholes in one side.
17	2	—	0·72	0·73	0·74	467,400	Broke No. 3 link. Section shows small shrinkage one side. See also dynamic test No. 7.

TABLE II.—DYNAMIC TENSION TESTS OF CHAIN.

Test No.	Size.	Material.	Elongation, in., after Three Blows at 5 ft.	10 ft.	15 ft.	20 ft.	25 ft.	Total Blows at 25 ft.	Total Blows at 30 ft.	Total Blows at 35 ft.	Chain Broke on	Total Elongation.	Remarks.
	in.												
1	2	Wrought ..	0·02	0·05	0·15	—	—	—	—	—	1st at 20 ft.	0·15	*
2	2	Wrought ..	0·00	0·02	—	—	—	—	—	—	2nd at 15 ft.	0·02	†
3	2	Wrought ..	0·00	0·02	—	—	—	—	—	—	2nd at 15 ft.	0·02	‡
4	2	Naco.. ..	0·01	0·05	0·09	0·13	0·27	50	20	—	None	0·65	§
5	2	U.S. Navy ..	0·10	0·34	0·68	1·37	2·21	6	—	—	6th at 25 ft.	—	‖
6	2	U.S. Navy ..	0·06	0·32	0·74	1·32	2·08	10	2	—	None	3·85	¶
7	2	Naco.. ..	0·02	0·02	0·03	0·05	0·10	10	1	—	None	0·72	**
8	2	Naco.. ..	0·08	0·10	0·15	0·19	0·27	10	10	10	1st at 30 ft.	0·24	

* Broke Nos. 4 and 5 links. † Broke No. 1 link. ‡ Broke No. 1 link through weld. § Chain installed in static machine. See static test No. 15. ‖ Surface fractures in all links. Chain installed in static machine and broke No. 2 link at about 241,000 lb. ¶ Broke No. 4 link. Section shows solid. ** Chain installed in static machine. See static test No. 17.

* Paper read before the American Society for Testing Materials.

impossible to deliver the full blow to the chain. The elongation over three links was 3·85 in., and each of the five links was slightly fractured in one or more places. After the third blow at 20 ft. the elongation over three links was 1·32 in., and after the third blow at 25 ft. it was 2·08 in. Undoubtedly this chain was out of commission on account of distortion so far as serviceability is concerned after the third blow at 25 ft.

Results of Static Tests.—Static tests Nos. 13 and 14, on 2¼-in. Naco chain, were made on test specimens having serious shrinkages on one side of the No. 3 link opposite the stud, for the purpose of determining the effect of these defects. In test No. 13 the defective link broke through the defect at 502,400 lb., and in test No. 14 the No. 5 link broke at 491,900 lb., showing solid sections at the fracture. The second chain was retested, finally breaking through the defect in No. 3 link at 502,200 lb. While neither of these chains would have been considered suitable for commercial purposes and the defects would have been readily detected on a casual inspection, it is quite interesting to note the slight effect of the imperfections.

Great Progress Made.—Some reference should be made to our experience in the railway car-coupler field during the past twenty years, for the reason that experience has made possible the accomplishment of results in the cast steel chain problem in a few weeks which otherwise would have taken several years to attain.

The knuckle of the Master Car Builders' vertical-plane type of coupler has involved a very serious and difficult problem, particularly in the past ten years. Since the adoption of the standard Master Car Builders' contour for that coupler in the early 'nineties, a standard which, because of the requirements of interchangeability, has remained substantially without change up to the present time, there have been enormous increases in locomotive tractive effort, size and weight of car equipment and tonnage hauled per train. The limitations of the Master Car Builders' contour, formed partly by the coupler head, and partly by the knuckle, have imposed certain fixed dimensions upon the size of the hub of the knuckle, its weakest point, which have effectually barred any substantial increase in section. The stress to which this hub section is subjected is really enormous, for the knuckle, which is in the form of a hook pivoted at its middle, transmits not only the entire tractive effort of the locomotive in pulling the train, but also receives shocks of great suddenness and intensity, both jerks and buffs, due to the surging of trains, the running out and in of "slack" during application and release of brakes, and in coupling by impact. Dynamometer car records have shown time and again that these pulls and buffs are frequently many times in excess of the tractive effort of the largest modern locomotives.

Notwithstanding the evil effects of knuckle distortion upon proper maintenance of contour, it has been felt for years that nothing but a material with high ductility would be capable of receiving these severe shock stresses. Part of the basis for this feeling has been the theory that a very ductile material would, by its elongation, absorb some of the shock and so save itself from rupture, but the difficulty with this is that the major part of this elongation is available only after the elastic limit of the material has been passed.

Have Standard Steel Coupler.—Two possible solutions for this problem have presented themselves, the use of a special material with much higher capacity to resist both static and dynamic stresses, and the adoption of an entirely new and heavier coupler with modified contour, having sufficient sectional areas to make resort to special materials unnecessary. The latter method was followed by joint action of all the coupler manufacturers, under the initiative and jurisdiction of the Master Car Builders' Association, and to-day, after six or seven years' development, we have one standard coupler, somewhat heavier and very much stronger and with its knuckle able to meet the demands of service, though made of ordinary open-hearth steel.

Investigate Material.—In the meantime, realising the importance of the problem, and the probable length of time involved in developing a standard coupler, we began an exhaustive search for a suitable special material to use in our knuckles. In the early days we started making couplers by the acid open-hearth process, later changing to basic, but our experience with both these steels led us to believe that there was no possibility of increasing the tensile strength sufficiently without loss of ability to withstand shock which would only result in failure to withstand the required Motor Car Builders' drop tests, which tended to compel the use of a soft material. We then began a series of experiments in the electric furnace with high-carbon steels heat treated, and later with alloy steels. Marked improvements in tensile strength were the result, but the ability to withstand shock did not increase and in many cases was diminished. Finally we arrived at a special material to which we later gave the name "Naco" steel, which combined with a high tensile strength extraordinary ability to withstand shock.

This material now used in our coupler knuckles, has raised their elastic limit more than 225 per cent., and their ability to resist shock stresses nearly 100 per cent., over ordinary open-hearth steel. The amount of shock which these knuckles will take without breakage or serious distortion is beyond anything in our experience, and we have been able to develop a specification of our own, along the lines of Motor Car Builders' coupler specifications, but calling for only half the amount of knuckle distortion with the same amount of shock in the drop test, a feature of the greatest advantage in the maintenance of proper contour in service.

Our inspection department is using this Motor Car Builders' drop-testing machine daily in the acceptance or rejection of our knuckle steel heats, and make on the average of 3,000 tests per year. The performance in this machine is borne out in service by the record of more than 1,000,000 knuckles in use without a report from any railroad or from our road service department, of a single failure of a knuckle since the experimental period was passed.

There are so many points of resemblance between the coupler-knuckle problem and that of cast steel chain as we understand it, that we were able to start at a point which otherwise must have taken years of study and development, with the results set forth. In our opinion, a proper specification for cast steel chain would require the making of links in dry sand moulds or cores, but other details of manufacture should be left optional with the manufacturer. For the chemical requirements, the steel should be made by the electric furnace process, with phosphorus and sulphur limits of not over 0·04 per cent. The physical requirements should be sufficiently rigid to insure sound material and should embody a dynamic test sufficiently severe to put the ability of the steel to withstand shock beyond any question of doubt. For this latter purpose we believe the standard Motor Car Builders' drop-testing machine presents the most readily available commercial machine, and a shock test on short pieces of test chain similar to the tests carried out at our Sharon plant seems to be as closely representative of the service to which anchor chain is subjected as any laboratory test can be.

CATALOGUES.

Asbestos.—The second and third numbers of the monthly periodical *Asbestos*, issued by Messrs. Turner Brothers Asbestos Company, Limited, Rochdale, maintain a high standard of local and technical interest.

Books.—The catalogues issued by Mr. William Downing, bookseller, 5, Temple-row, Birmingham, always contain a fine selection of classical works, folk-lore, travel, science and general literature. Of course technical books take a small space, but there are generally a few, as in the July catalogue.

Generating Sets.—A catalogue of spare parts and instruction book for their small engine generating sets has been issued by the Austin Motor Company, Limited, Northfield, Birmingham. The sets are, in kilowatts 3, 3·5, 8 and 18. Illustrations and lists are given clearly. The price of the catalogue is 4*s.* 6*d.*

Electric Lanterns.—A projector lantern for throwing a beam or flood of light is described in a catalogue from the British Thomson-Houston Company, Limited, 77, Upper Thames-street, E.C. 4. It is mounted on a tripod stand with swivelling fittings. The mirror diameter is 13 in. It should be very useful for yard work, shunting, work on outside of buildings, &c.

Steam Winches.—For pile driving and hauling a steam-driven gear is made by the British Steel Piling Company (Edward Le Bas), of Dock House, Billiter-street, E.C. 3. The boiler is vertical, the engine two-cylinder horizontal; these, with the drums and gear wheels, are mounted on a single baseplate which may be carried on wheels. The clutch is of the friction type. There are eight sizes listed to work piling hammers of 15 cwt. to 5 tons. Drop hammers, sheaves and standards are also shown in the catalogue.

Tool Steel.—Circulars describing two special tool steels come from Edgar Allen and Co., Limited, Sheffield. "Red Label" is a tungsten crucible steel for twist drills, taps, milling cutters, reamers, &c. It is not a high-speed steel but it will stand a higher friction heat than ordinary tool steel, and the tungsten makes it stronger against torsion. It is hardened in clear water. "K 9" steel is for similar work, but is specially prepared to harden with the least possible distortion. It hardens by quenching in oil. Both steels are delivered annealed ready for cutting to shape.

Concrete Mixer.—Mixing what is called semi-wet concrete is a particularly difficult thing to do mechanically though it obviously should be machine work and not left to hand labour. Messrs. Winget, Limited, 25, Victoria-street, S.W. 1, are producing a mixer suitable for dry, semi-wet or wet work. It is mounted on a truck forming, with a paraffin engine, a complete portable unit. The paddles are shovel shaped, with the shovel blades made of chain and set at an angle of about 45 deg. to the axle of the mixer. The one size at present made mixes a charge of 3 cub. ft. and 60 charges per hour. A larger size is in preparation.

Normalising Carbon Steel.—A little leaflet on this subject issued by the Automatic and Electric Furnaces, Limited, 6, Old Queen-street, S.W. 1, explains the importance of normalising after annealing and before cutting the steel to shape. The matter is important both from the point of view of saving the cutting tools employed on making gauges, &c., and from that of finally getting the finished gauge into the best wearing condition. After normalising and before cutting it is recommended that the thin oxide skin should be removed by lapping with carborundum powder and vaseline. About two runs with the lap will be enough.

Standard Piston Rings.—No man should lightly write a fourth figure after a decimal point. That is the gist of an excellent little pamphlet on standardisation, issued by the British Chuck and Piston Ring Company, Limited, Holbrook-lane, Coventry. It contains some good advice for designers. The advantage of using standard manufactured parts where possible, and the useless expense and delay caused by prescribing unnecessarily fine limits, are not generally recognised. The pamphlet very properly emphasises the folly of going beyond one thousandth of an inch in any but the most exceptional work. The company issues standard dimension lists for piston rings, gudgeon pins, shackle bolts and greasers.

Marine Oil Engine.—A two-stroke four-cylinder oil engine of 300 h.p. is described in a catalogue issued by the Evinrude Motor Company (England), Limited, 107, Waterloo-road, S.E. 1. Heavy oil fuel may be used and is injected into a vaporiser-box on the cylinder head where the heat is enough to vapourise but not to ignite it. A blast of high-pressure hot air then sweeps the charge through a sieve into the cylinder, where it is ignited by a red-hot nickel-steel firing plug. The scavenging air is from the crank-case. The engine is started by compressed gas and is directly and quickly reversible on fuel. Cylinder bore and stroke are not stated, but the four-cylinder engine develops 300 brake horse-power at 200 r.p.m., the total weight being 16 tons.

Engineers' Supplies.—The variety of supplies described in a small booklet catalogue issued by the County Chemical Company, Limited, Bradford-street, Birmingham, would not be indicated by the term "chemicals" in its everyday sense. Amongst them are abrasives in powder and paste; adheseives for leather, glass, wood and rubber; celluloid cement; acid-proof varnish; brazing and welding fluxes and compounds, including paste for preventing solder adhesion at any required parts; casehardening powders; tempering powder, and welding plates for band saws, box-corner welding, &c. The firm make a scientific study of the composition and manufacture of these supplies, and will send copies of the booklet to any of our readers on request.

Gas and Petrol Engines.—The Keighley Gas and Oil Engine Company, Limited, send a catalogue of their vertical engines for town gas and for petrol fuel. These are made in stationary industrial, portable industrial, and electric generating forms. The cooling water is circulated by centrifugal pumps in four-cylinder engines and by thermo-syphon in one and two-cylinder engines. All parts are standardised and interchangeable with new parts from stock. About 12 sizes, ranging from about 4 h.p. to 45 h.p., are standard. Any of the usual spirits up to 0·760 specific gravity may be used. The difference of powers developed by fuels are as 20 on town gas to 21 on petrol. Various units are shown in which the engines are coupled to electric generators, air compressors, centrifugal pumps, concrete mixers, rock drills, and various agricultural machines. A portable farmer's engine is also shown for general agricultural work mounted with water and fuel tanks on a substantial four-wheel truck. These engines are of a neat and clean design and high quality of material and workmanship.

Iron Castings.—An extremely useful little catalogue and reference book comes from the Stanton Ironworks Company, Limited, Stanton-by-Dale, near Nottingham. It gives full particulars of straight lengths of cast-iron spigot and socket pipes, in diameters from 1½ in. to 48 in. with length, thickness of wall, weight per length and test pressures in feet-head and in pounds per square inch. These are obtainable in rough castings for lead joints, or turned and bored, or coated. There are four standard series for pressures in pounds per square inch of 175, 260, 347 and 433. Line drawings with all dimensions are given for the spigot and socket, rough and turned, and a great variety of bends, collars, plugs, elbows, tees, crosses, caps, tapers and branches. A similar body of information is given for flanged pipes and special standard parts such as tar wells, strainers, manhole covers, lamp-hole covers, ventilators and gullies. Segment plates, in cast-iron, for tube railways and well bores are now standard articles. We hear so much of steel nowadays that in some engineering circles the undying importance of iron castings, apart from machinery castings, may not be realised. This firm employs in its colliery, pig-iron and casting work, 7,000 men in normal times and over 23,000 h.p. in engines of various forms, with 90 steam boilers. Many useful tables of data are included.

Tool Steel.—It is recognised that the practical man has to depend on maker's catalogues for information about forging and heat treating tool steels: therefore many of these publications take the form of technical handbooks, with more or less of the commercial style. Among the best of such catalogues might be classed that of the Ludlum Steel Company, Watervliet, New York. It contains a good deal of explanatory matter which belongs to metallurgy rather than to tool-making; but this matter is written in plain language and should be helpful. In this section of the catalogue there are short chapters on the effects of nickel, chromium, vanadium, manganese and tungsten. Other chapters deal with forging, annealing, hardening and tempering. The Ludlum Company advise hardening carbon steel at the lowest temperature at which it will harden. Quenching at high temperatures does not give greater hardness and lowers the solidity of the steel. However great the hardness required it is best to temper a little to get the steel into good condition, so that the cutting edge may get full support from the material under it. Two qualities of high-speed steel are made, the second being suitable for less than the very severest work. A number of "bits" are also made in square section, from ¼ in. to ¾ in., with 30 deg. angle ends ready for grinding. These are to fit standard tool holders. Special alloy steels are made for taps and dies (non-shrinking), finishing cuts, pneumatic rivet sets, punches, dies, drawing dies, extension dies, twist drills, non-corrosive steel, and steels for ball-bearings and magnets. The steels for tools, are made in discs and rings as well as the usual sections. The extra charge for annealing is 1 cent per pound for carbon steel and 2 cents per pound for tungsten steel; this is interesting as proof that the makers attach real importance to slow heating and slow cooling under protective packing.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

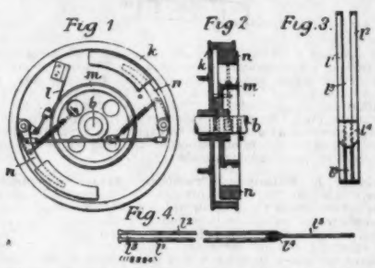
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

LIFTING AND HAULING APPLIANCES.

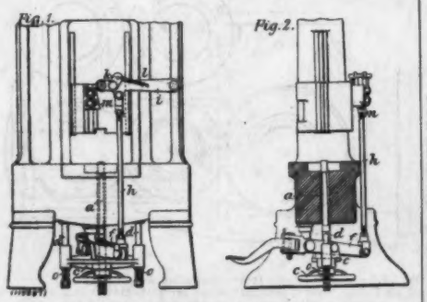
115,384. M. B. Wild, Erdington, Birmingham. Winches. (6 *Figs.*) April 20, 1917.—This invention relates to winches. Within the rim *k* at one end of the barrel of the winch an automatic brake is provided in the form of a clutch which can serve as a control connection between the barrel and the barrel shaft *b*. The barrel is loosely mounted on the shaft *b* and the latter is driven in one constant direction by a motor. When raising a load the barrel is operated from the shaft through gearing. The clutch or automatic brake comprises a brake band *l*, which completely embraces the disc *m* keyed to the barrel shaft *b* and is brought into service by centrifugal force acting on the interconnected weighted levers *n* carried within the rim *k*. Regulation to the desired speed limit is effected by adjustment of the retaining springs *o*. Excessive speed of the barrel in lowering a load by gravity is prevented by the automatic brake or clutch aforesaid, as any excess rate of rotation, or the tendency to such excess,



results in the barrel being clutched to the barrel shaft *b*, and as the latter is connected with its driving motor it serves as an effectual check on the speed of lowering. Control of the lowering within the speed limit fixed by the automatic brake or clutch is effected by a brake band which completely embraces the rim *k*. The brake bands *l* for the brake rim *k* and also for the brake disc *m*, are each comprised by a band, preferably of steel lined with suitable fibrous or other friction-creating material, which is made to form a circle to completely embrace the periphery of the rim. The greater length of portion of the band is made up of two steel strips *l*1, *l*2, of such width as to give a lateral cooling space *l*3 between them on the brake rim. To complete the ring or annulus for entirely embracing the rim the said pair of strips are at one end connected preferably by a plate *l*4 to a shorter strip *l*5 adapted to pass through the lateral space aforesaid. One end of the band is connected to the operating lever and the other to a fixed anchorage. (*Accepted May* 15, 1918.)

MINING, METALLURGY AND METAL-WORKING.

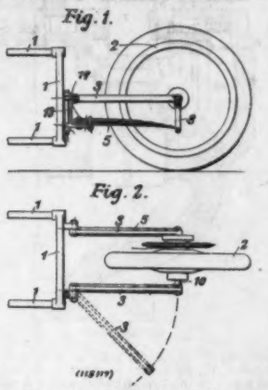
115,287. C. H. Hands, and John Hands and Sons, Limited, Birmingham. Power Presses. (May 11, 1917.—This invention relates to power presses for performing shaping or cutting operations on metal articles. The invention comprises the combination with an ejector *a*, of a slidable crosshead *c* connected thereto, a lever *f* pivoted on the crosshead and on the frame of the machine, a lever *i* pivoted on the frame of the machine adjacent to the plunger, a link *h* connecting the two levers, and abutment pieces *m*, *k*, on the plunger and the adjacent lever, the abutment piece *k* being hinged so that it can transmit motion only in one direction whilst the abutment piece *m* is adjustably



fixed on the part carrying it. During the upward stroke of the plunger, the abutment piece *m* engages the abutment piece *k* and lifts the latter, thereby causing the ejector to be raised. At a given position determined by the setting of the mechanism, the abutment piece *m* moves past the abutment piece *k* and allows the lever and ejector to return by gravity to the original position, springs *o* on the guides *d* serving to cushion the movement. During the downward stroke of the plunger, the abutment piece *m* moves idly past the abutment piece *k*, the latter piece being swung on the lever against the spring *l* by the first piece. After the parts have cleared, the second abutment piece is returned by the spring. (*Accepted May* 15, 1918.)

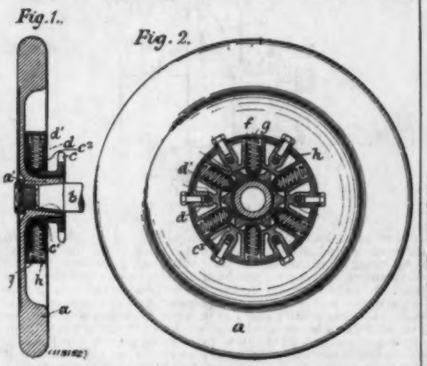
MOTOR ROAD VEHICLES.

115,117. J. H. Forknall, Leicester. Motor Road Vehicles. (3 *Figs.*) May 19, 1917.—This invention relates to motor road vehicles of the lighter class having three wheels and concerns the mounting arrangement of the single-gear wheel. The invention has reference to a wheel mounting arrangement wherein one side thereof is movable bodily from position to provide access to the wheel, or enable the latter to be completely removed. The invention consists of a construction of the mounting arrangement of the single wheel wherein one side of the supporting structure comprises a pivotally-movable bar, an associated spring, and a bracket or fitment mounted to turn upon a vertical axis and or be removable from the framework of the vehicle, the said bar and spring at one end being attached to the bracket or fitment, and at the other end being connected by links, the bar at the said



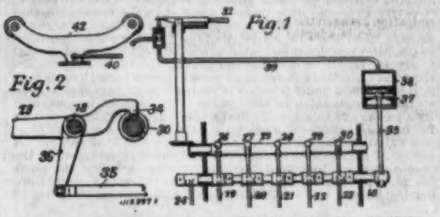
latter end being also adapted for attachment to the wheel axle, such as by a nut. From the back part of the frame 1, the rear driving wheel 2 is held by means of bars 3 arranged one on each side of the wheel, as shown in Fig. 2, said bars being pivotally attached to the frame whereby the wheel may have a rising and falling movement relatively to the frame. Situated underneath each bar 3 is a laminated spring 5 (Fig. 1). The ends of the wheel axle 10 pass through the outer ends of the bars 3. The bar 3, spring 5 and link 8 on one side of the wheel are mounted in such a manner as to be capable of being swung laterally outwards as indicated by the dotted lines in Fig. 2. For this purpose, the rod 3 and spring 5 are attached to a bracket 13 mounted to turn upon a vertical axis carried by the frame 1. (*Sealed.*)

115,152. W. Comery, Mapperley Park, Nottingham, and The Raleigh Cycle Company, Limited, Lenton, Nottingham. Transmission Gear. (2 *Figs.*) July 21, 1917.—This invention relates to the transmission gear of motor vehicles. The invention, which is particularly applicable to chain-driven motor cycles, consists essentially in the provision, upon one of the driving or driven members, of radially-disposed, spring pressed balls or plungers, which engage inclined surfaces formed upon a complemental driven or driving member. The fly-wheel *a* is keyed to the crank shaft *b*. Rotatably mounted on the fly-wheel boss *a*1 is a sprocket wheel *c* having an extension *c*1 in the periphery of which a series of concave recesses *c*2 are formed, the inclined sides of which lie transversely of the axis of said extension. A ring-like fitting *d* is secured to the flywheel *a* by means of



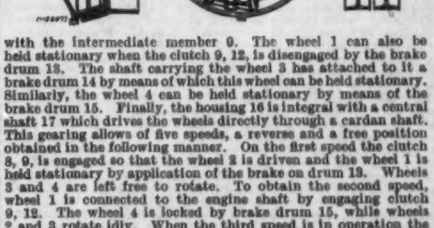
the screws *e*, said fitting being bored to fit over the sprocket wheel extension *c*1. The fitting *d* is bored with radial holes *d*1 to receive plungers *f* whose inner ends abut against the inclined surfaces *c*2, said plungers being forced into engagement with said inclined surfaces by means of springs *g*. The latter are kept in position by means of a ring or hoop *h* secured to the fitting *d* by means of set pins. In the event of varying impulses of the motor, the abnormal impulses cause the plungers to momentarily ride up the inclined surfaces thereby compressing the springs *g*, which act absorbs the sudden impulse or acceleration instead of transmitting it to the driven member *c*. The recesses *c*2 constitute grooves and the engagement of the plungers *f* in said grooves also serves to maintain the driven members *c* in position axially on the shaft. (*Sealed.*)

115,397. Leyland Motors (1914), Limited, Leyland, and J. G. P. Thomas, Barnes. Variable-Speed and Torque Gearing. (3 *Figs.*) May 3, 1917.—The invention relates to improvements in operating mechanism for variable-speed and torque gearing. According to the present invention, the operation of the members for changing speed is effected by means of a selector shaft carrying a series of fixed collars or flanges, each formed with a notch or socket to engage with the tooth-shaped or pin-shaped end of one of a series of pivoted levers used for actuating the speed-changing members. This shaft, when rotated, allows the necessary combination of the brakes and clutches to become operative, while on the other hand the operating members in any gearing position positively lock the selector shaft so that it cannot be rotated until all the brakes and the clutches are freed again. There are five levers pivoted about a shaft 18, and connected respectively to a first clutch, a second clutch, the band upon a first brake drum and the bands upon second and third brake drums. These levers are shown at 19, 20, 21, 22, 23. A foot pedal is connected to lever 24, and when this pedal is depressed all the brakes and clutches are taken out of operation. If the pedal is released, however, there is a tendency for all these devices to be brought into operation by springs. However, only certain of them can go into operation owing to the effect of a selector shaft 25. This has five notched discs or cams 26, 27, 28, 29, 30. The selector shaft is rotated by a control handle 32. As this is turned into positions corresponding to different arrangements of gearing, certain of the notches in the discs 26, 27, . . . allow fingers such as 34 to drop into the notches in the corresponding discs, and then the members con-



trolled by the levers, such as 23, are brought into action by their springs. The finger 34 in each case when it drops into the corresponding notch locks the gear until all the members are released by depressing the pedal or by means of the following mechanism. The shaft 18 can also be rocked by means of the connecting rod 35 and crank lever 36 when the former is pulled up owing to the suction on the back of the piston 37 working in the cylinder 38. The space in the cylinder 38 is connected by pipes 39 and 40, through a piston valve 41, to the induction pipe 42 of the driving engine, at a point above the throttle valve. In operation, if the engine is running with the throttle valve closed or only partly open there is sufficient vacuum transmitted through the pipes 40 and 39 to draw in the piston 37 so that the shaft 18 is rocked sufficiently to withdraw the clutches and disengage the band brakes. (*Accepted May* 15, 1918.)

115,267. Leyland Motors (1914), Limited, Leyland, and J. G. P. Thomas, Barnes. Power Transmission. (1 *Fig.*) May 3, 1917.—The present invention relates to improved means for providing a variable speed and torque ratio between a load shaft and its prime mover, and more particularly provides a convenient gearing for providing the necessary variation of speed and, torque in motor vehicles driven by internal-combustion engines. According to this invention, a pair of planetary wheels are rigidly coupled by a shaft rotatable in a housing which is secured to or integral with the load shaft, each of said planetary wheels being in gear with two sun wheels, with which they engage respectively on opposite sides of the load shaft, the axis of the shaft of the planetary wheels being inclined to and cutting the axis of rotation of the sun wheels. In the form shown, the gearing comprises four sun wheels 1, 2, 3, 4, all capable of rotation about a common axis but free to rotate independently of one another. In addition, there are two planet pinions 5, 6, coupled together by the spindle 7. The member 5 engages with the members 2 and 3, and the member 6 with the members 1 and 4 respectively. The sun wheel 2 is mounted in bearings and connected rigidly to an internal clutch member 8 which can be brought into engagement with an intermediate clutch member 9. This latter, through the arms 10, is connected to the shaft 11 driven by the other prime mover. The sun wheel 1 is also capable of being driven by the prime mover because it is connected directly to the outer clutch member 12, which also can be engaged

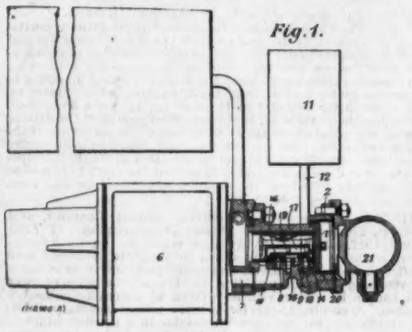


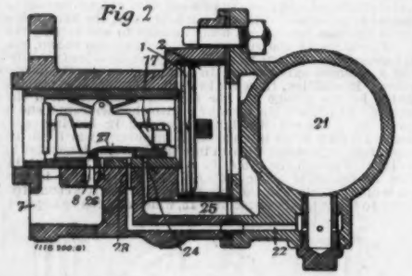
with the intermediate member 9. The wheel 1 can also be held stationary when the clutch 9, 12, is disengaged by the brake drum 13. The shaft carrying the wheel 3 has attached to it a brake drum 14 by means of which this wheel can be held stationary. Similarly, the wheel 4 can be held stationary by means of the brake drum 15. Finally, the housing 16 is integral with a central shaft 17 which drives the wheels directly through a cardan shaft. This gearing allows of five speeds, a reverse and a free position obtained in the following manner. On the first speed the clutch 8, 9, is engaged so that the wheel 2 is driven and the wheel 1 is held stationary by application of the brake on drum 13. Wheels 3 and 4 are left free to rotate. To obtain the second speed, wheel 1 is connected to the engine shaft by engaging clutch 9, 12. The wheel 4 is locked by brake drum 15, while wheels 2 and 3 rotate idly. When the third speed is in operation the wheel 2 is driven by the engine, the wheel 3 is held stationary by the brake drum 14 and the wheels 1 and 4 rotate idly. The fourth speed is the direct drive, the whole gearing being locked solid by engaging clutches 8, 9, and 9, 12, so that wheels 1 and 2 are both driven at engine speed. The shaft 17 rotates at engine speed, and therefore receives the full engine torque. A fifth speed can be obtained by coupling the engine to the wheel 1 while the gear wheel 3 is held stationary. In order to obtain the reverse speed, clutch 8, 9, connects the wheel 2 to the engine and the wheel 4 is locked by the brake drum 15. The wheels 1 and 3 rotate idly. (*Accepted May* 15, 1918.)

RAILWAYS AND TRAMWAYS.

115,300. J. W. Cloud, London. Fluid Pressure Braking Apparatus. (4 *Figs.*) May 18, 1917.—This invention relates to fluid pressure braking apparatus of the description in which a triple valve device, employed in conjunction with the usual auxiliary reservoir, operates to control the supply of fluid under pressure not only from the auxiliary reservoir to the brake cylinder, but also from a supplemental reservoir, the supply of fluid from the latter being utilised for the purpose of taking up the slack of the brake rigging and obtaining a quick contact of the brake blocks with the wheels when the brakes are applied. According to the present invention, both the charging of the supplemental reservoir and also the connection of the same to the brake cylinder for braking purposes is effected wholly by means of the slide valve of the triple valve without the intermediary of any additional valve, the connection of the supplemental reservoir to the brake cylinder being effected through

relatively large ports and passages in the triple valve simultaneously with the connection of the auxiliary reservoir to the brake cylinder through ports and passages of the usual somewhat restricted dimensions. The triple valve comprises the usual piston 1 located within a cylinder 2 subject on one side to the pressure existing in the train pipe and on the other side to the pressure existing in the auxiliary reservoir and controlling the operation of a slide valve and graduating valve in well-known manner. The brake cylinder 6 communicates with a passage 7 terminating in a port 8 in the slide valve seat. The passage 7 is also connected to a port 9 in the slide valve seat. The supplemental reservoir 11 is connected to a passage 13 terminating in a port 14 in the slide valve seat. A port 15 in the slide valve seat leads to the atmosphere. The slide valve 16 comprises the usual graduating valve 17 controlling the supply of fluid to a port 18 adapted in the application position to register with the port 8. A cavity 19 in the slide valve is adapted in the release position to establish communication between the ports 9, 15. A restricted passage 20 in the slide valve is adapted in the release position to permit a restricted communication between the supplemental reservoir and the slide valve chamber. The improvements are shown as embodied in a triple valve of the type comprising a bulb into which fluid under pressure is vented from the train pipe upon an initial application of the brakes. The bulb 21 is connected by a passage 22 to a port 23 in the slide valve seat, and a port 24 in the slide valve seat leads by a passage 25 to the train pipe. A port 26 in the slide valve seat leads to the atmosphere. A cavity 27 is provided in the slide valve and is arranged in the release position to establish communication between the ports 23, 26, and in the application position to cut off such communication and to establish communication between the ports 23

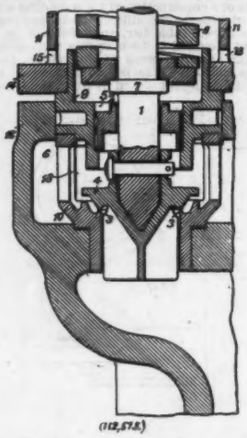




and the port 24 leading to the passage 25 and to the train pipe. The parts are shown in the release position of the parts. When a reduction in the train pipe pressure is made, the triple valve parts assume the application position and fluid is supplied to the brake cylinder in the following manner. In the first place the cavity 19 establishes communication between the ports 14, 9. Accordingly the supplemental reservoir 11 is placed in direct communication with the brake cylinder. At the same time the graduating valve 17 supplies fluid directly from the slide-valve chamber and the auxiliary reservoir 3 to the brake cylinder through the ports 18 and 8. The supplemental reservoir 11 is connected to the brake cylinder in the application position since the cavity 19 connects the ports 9 and 14 and the fluid under pressure admitted from the auxiliary reservoir 3 increases the pressure both in the brake cylinder and in the supplemental reservoir 11. If, therefore, the brakes be finally applied with full force, the pressures in the auxiliary reservoir 3, the supplemental reservoir 11 and the brake cylinder 6 will be equal, and when the triple-valve piston is moved to the release position, the brake cylinder only is vented to the atmosphere and the supplemental reservoir 11 remains charged with fluid under pressure, and is further recharged from the slide-valve chamber through the restricted port 20 in the slide valve. When the slide valve 16 is moved to the application position, the cavity 27 in the slide valve connects the ports 23 and 24 thereby venting fluid under pressure from the train pipe by means of passage 25 directly to the bulb 21, through the passage 22. In the release position communication is cut off between the ports 23 and 24 and the port 23 is connected to the port 26. Fluid under pressure is thus vented from the bulb 21 in the usual way. (*Accepted May* 15, 1918.)

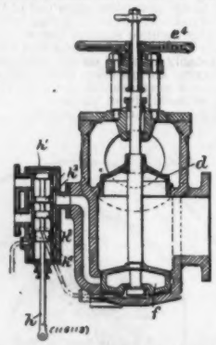
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

112,575. Cockburns, Limited, D. Cockburn, and D. Macnicoll, Cardonald, near Glasgow. Safety Valves. (1 *Fig.*) May 21, 1917.—This invention relates to safety valves of the type fitted with a balancing member above the valve. The invention consists in a construction including a cage member surrounding the valve spindle, said cage member presenting a valve seat and being formed with a cylindrical chamber in which the balancing member or piston is movable. There is fitted to surround the valve spindle 1 a balancing piston 2 of greater area than the cross-sectional area of the opening at the valve seat 3, there being sufficient clearance between the piston 2 and the spindle 1 to ensure that the spindle 1 and the valve proper 4 may be free to move in the event of the piston 2 binding. The piston 2 is movable in a cylindrical chamber 5 in communication with the waste fluid space 6, so that when the valve proper 4 rises from its seat the available pressure acting on the underside of the piston 2 will serve to lift the piston 2 independently of the spindle 1, assuming that it has not risen with the spindle 1. On the spindle 1 above the piston 2 is a collar 7 which forms an abutment for the spring 8. Normally when the valve 4 and the spindle 1 rise, the spindle 1 passes through the piston 2, which remains stationary for the time being; the piston 2 being subsequently lifted by the action of the fluid pressure thereon, and impacting the collar 7 so that an impetus is imparted to the spindle 1 in the direction to lift the valve proper 4. It will thus be seen that the valve 4 can function as a safety valve independently of the piston 2, being only dependent on the piston 2 for increased lift. The cylindrical chamber 5 is formed in the upper part 9 of a two-part cage member, of which the other part 10 is formed with the valve seat 3, such cage member being



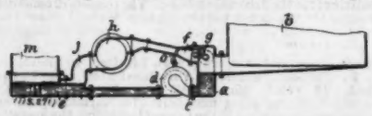
secured in position by the same bolts as secure the cover 11 of the valve casing 12, such cage member 9, 10 being provided with ports 13 whereby the cylindrical chamber 5 communicates with the waste fluid space 6. The wall of the upper part 9 of the cage member preferably extends above the flange 14 of the cover 11, which latter is provided with an outlet or outlets 15 for water or condensation, the wall of the upper part 9 of the cage member acting as a dam, so as to prevent accumulation of water and formation of rust within the casing 12. (*Sealed.*)

115,113. J. C. Grant, Cardonald, Glasgow. Stop Valve. (1 *Fig.*) May 14, 1917.—In accordance with this invention, the valve *d* is connected to a piston *f* open to boiler pressure, and having an area sufficient to normally retain the valve upon its seat, whilst the space behind the said piston communicates with a slide valve *h*, so that the pressure behind the piston may be relieved, thereby allowing the valve to close, in the known manner. The piston *f* is preferably stepped or made with a shoulder and the larger diameter works clear in its casing and the pressure required for starting purposes is adapted to escape past the piston. The actuating slide valve *h* is preferably made with a rod having four piston members *h*1, *h*2, *h*3, *h*4, adapted to open



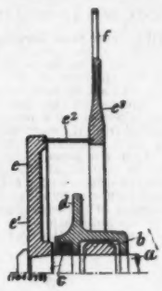
or close ports leading to the piston, to the engine cylinders, to the space behind the piston, and to the drain tank, the arrangement being such that on the slide valve being operated to open communication between the back of the piston *f* and the drain tank, the main valve *d* is held on its seat, due to the greater area of the piston and the absence of pressure behind the latter. The main valve has a hand wheel *e*4 or lever and screw sleeve or the like, which may be operated so as to release the valve, but without opening same, and on the slide valve being moved into position to shut off communication to cylinders and to drain tank, full boiler pressure is allowed to accumulate behind the piston, so that the main valve is opened by the steam pressure. (*Sealed.*)

115,271. The Hon. Sir C. A. Parsons, S. S. Cook and R. Howe, Wallsend-on-Tyne. Condensing Plant. (1 *Fig.*) May 3, 1917.—The present invention relates to condensing apparatus in which there are provided ordinary exhausting means such as a wet air pump and special vacuum-augmenting means, and in which an auxiliary pump is provided in the suction pipe connecting the ordinary exhausting means with the condenser outlet to prevent the return of non-condensed vapour or



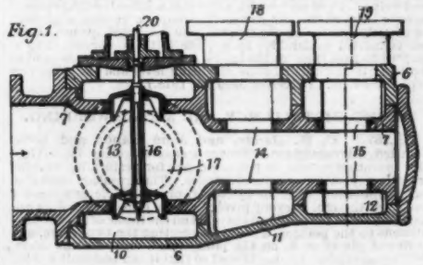
air to the inlet or suction of the augmenting means. The present invention consists in providing a small pipe from the upper part of the auxiliary pump casing to allow air or vapour to leak off to a part of the system which is at a lower pressure. A sump *a* is provided on the lower part of the main condenser *b*. At the lower part of this sump an outlet *c* is provided, connected to a pump *d*. The delivery from this pump is taken to the inlet *e* of the ordinary exhausting means, which may consist of a pump *m* of the bucket type. The upper part of the sump *a* is connected to the coned inlet *f* of an augmenter. At about the base of the coned portion of this conduit the usual diverging steam jet *g* is provided, the discharge from which, together with the entrained vapour and air is led to the usual vapour condenser *h* from which a passage *j* leads to the inlet *e*. At the top of the pump chamber *d* there is provided a pipe *o* leading from the top of the chamber *d* to the upper part of the sump *a*, which is at the main condenser pressure. A permanent leak off to a lower pressure part of the system is thus provided on the top of the rotary pump casing which will prevent accumulation of air therein. Any air or vapour which gets into this pump casing will pass off through the pipe *o* to the inlet or suction of the augmenting device, and will thus be prevented from interfering with the effectiveness of the rotary pump. (*Accepted May* 15, 1918.)

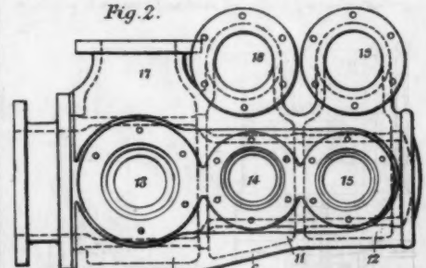
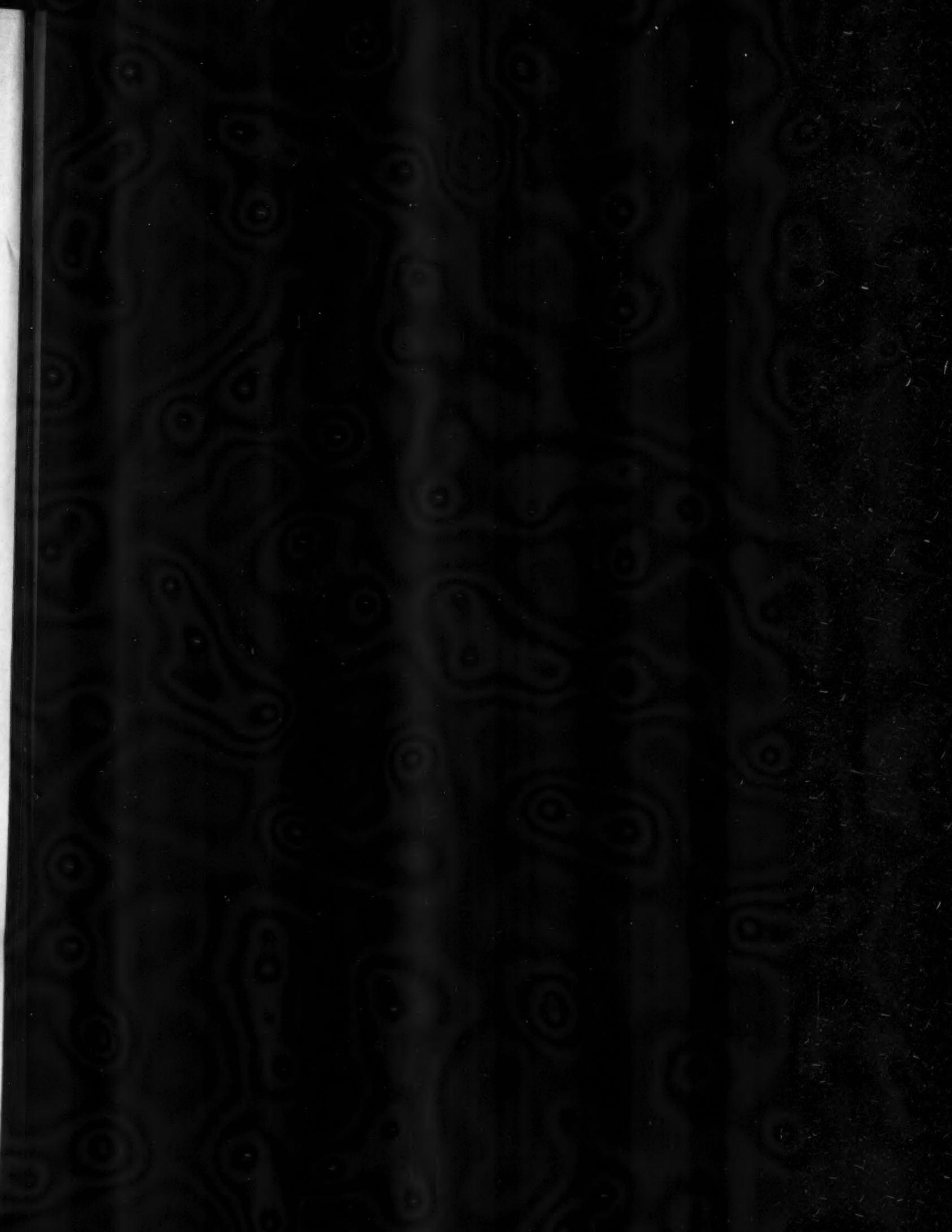
104,878. The Brush Electrical Engineering Company, Limited, London. (*Svenska Turbinfabriks Aktiebolaget Ljungstrom, Finspong, Sweden.*) **Turbines.** (1 *Fig.*) March 14, 1916.—This invention relates to turbines. *a* is the turbine shaft, *b* the bearing therefor, and *c* a packing to prevent the escape of elastic fluid around the shaft to the atmosphere, and into the bearing from the rotor chamber in the casing *d*. On the overhanging end of the shaft is mounted the rotor *e*, comprising a disc *e*1 which is rigidly secured to the shaft and a



second member *e*3 which surrounds the shaft and occupies a plane passing perpendicularly therethrough. The two members are connected by an annular element *e*2. The rim of the member *e*3 is thickened somewhat to provide a support for rows of radially-extending blades *f*. The annular element *e*2 forms an expansion ring. It will be evident from the foregoing that the rotor members *e*1 and *e*3 will be capable of expanding and contracting independently of each other and that stresses in one part will not be transmitted to the other. (*Sealed.*)

115,245. K. Baumann, Urmston. Steam Turbines. (3 *Figs.*) April 30, 1917.—This invention relates to steam chest for steam turbines of the kind in which a plurality of governor or hand-controlled valves are provided for regulating the supply of steam to a plurality of nozzle boxes or steam admissions. The steam chest consists of outer and inner chambers 6, 7, the interior of the outer chamber 6 and the exterior of the inner chamber 7 being provided with a plurality of circumferential ribs which divide the space between the two chambers into a plurality of separate compartments 10, 11 and 12. Ports 13, 14 and 15 provide communication between the interior of the inner chamber 7 and the compartments 10, 11 and 12 respectively. The ports 13, 14 and 15 are controlled by double-beat valves, only one valve, 16, however, being shown. Each of the valves may be separately actuated, either manually or automatically by the governor, as may be desired, by its own spindle 20. A passage 17 leads from the compartment 10, and other passages





18, 19, lead respectively from compartments 11 and 12 by means of which the several compartments are respectively connected to the various nozzle boxes or steam admissions of the turbine. In operation steam is admitted to the interior of the chamber 7, and assuming the valve 16 to be open and the valves controlling the ports 14, 15, closed, will pass through the ports 13 into the chamber 10 and from thence through the passage 17 to the steam admission with which this passage is connected. As the load on the turbine increases the valve controlling the ports 14 will be opened and steam will then also pass from the interior of the chamber 7 to the compartment 11 and passage 18 to another part of the steam admissions of the turbine. Similarly with a further increase of load the valve controlling the ports 15 will be opened and steam will also then pass through the passage 19 to the turbine. (*Accepted May* 15, 1918.)